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FEASIBILITY STUDY TO PREDICT COMBAT EFFECTIVENESS FOR SELECTED MILITARY ROLES: FIGHTER PILOT EFFECTIVENESS

FINAL REPORT

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FEASIBILITY STUDY TO PREDICT COMBAT EFFECTIVENESS FOR SELECTED MILITARY ROLES: FIGHTER PILOT EFFECTIVENESS

29 APRIL 1977 **MDC E1634**

FINAL REPORT

Edward W. Youngling
Sheldon H. Levine
John B. Mocharnuk
Louise M. Weston

This study was sponsored by the Defense Advanced Research Projects Agency and conducted under the technical monitorship of Dr. Harold F. O'Neil, Jr. Dr. Edward R. Jones directed the study. Dr. Philip H. DuBois acted as technical consultant. Joe A. Fitzgerald acted as coordinator for pilot matters. Edmund H. Conklin provided senior editorial assistance.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

History has demonstrated that there is a pressing need for improved selection, training, and management procedures among fighter pilots. In World War II, only one in twenty pilots became an ace. The U.S. Air Force kill ratio in Southeast Asia was approximately 2.5 to 1. In contrast, the Israelis claim to have a kill ratio of 60 to 1.

This feasibility study focuses upon enhancing our record of air-to-air combat kills through more stringent and comprehensive selection procedures. (Cont. on p. iii)

Specifically, this document presents empirical evidence which demonstrates that a program can be developed to select pilots who will be effective in air-to-air combat.

The development of a selection program of this nature requires the execution of several phases. These phases include a job analysis of the fighter pilot task, the generation of testable trait hypotheses, the development of predictor variables and peacetime and combat criteria, and validation and cross validation during peacetime and during combat. In this study, an extensive and comprehensive job analysis was performed, hypotheses were established, selection tools were assessed, peacetime and combat criteria were reviewed, and programs were outlined for the execution of the peacetime and combat validation phases.

From reviews of U.S. and foreign selection research dating from World War II to the present and an assessment of pilot opinion from hundreds of aces, 45 factors were identified as potential predictors of combat effectiveness. Of these 45 factors, only 10 are adequately evaluated within a current U.S. military selection program upon initial entrance into pilot training. Assessment of the 35 untapped factors is within our technological reach. In fact, many of these factors can be assessed by tests which are presently available.

An Air Combat Effectiveness Study (ACES) program is recommended which would provide selection test measures for virtually all of the factors identified as underlying combat effectiveness. As part of the ACES program, selection test measures would be correlated with performance in air combat maneuvering ranges, thereby providing a method for selecting fighter pilots during peacetime. Also included in the ACES program is a combat data acquisition and validation plan.

Armed with these selection test scores and an effectively executed validation program, researchers will, for the first time in history, be able to specify a definitive profile of the ace fighter pilot.

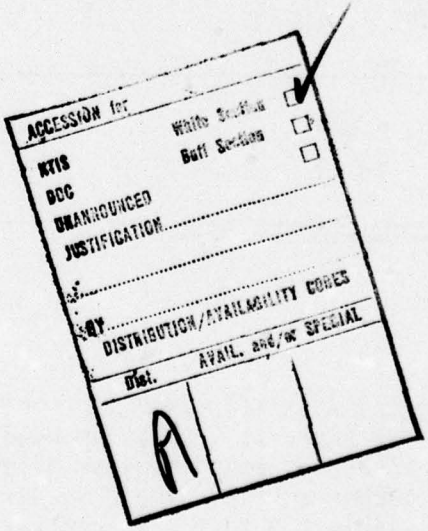


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NOTE TO THE READER

If you are unable to read this entire document, the guide below may be used to help you select reading material and depth.

	Level	Read Sections	No. of Pages
o Shortest reading	overview, narrative	1.1	5
o Recommendations resulting from this effort	narrative	7	20
o Support for recommendations			
o Pilot inputs	narrative, summary charts	2; 3.6	35
o Literature review and issue analysis	detailed narrative, source citations, detailed exposition of data	3 (excluding 3.6)	87
o Interim integrative and developmental steps	detailed narrative	4, 5	23
o Simulators and combat maneuvering ranges	detailed narrative	6	31

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1.0 EXECUTIVE SUMMARY AND INTRODUCTION

1.1 EXECUTIVE SUMMARY

In World War II we sent large numbers of pilots to war, some of whom survived their early combat engagements, became skilled at their craft, and went on to become aces - but they were the one in twenty. Today, uncontestably, we must find a way to better select, train, and manage our most valuable resource, the pilot.

"Any fighter pilot" can tell you how to improve air-to-air combat effectiveness - find a good way to select a man for air-to-air, give him specialized training, and keep him in the cockpit. The Israelis do it this way and claim a 60 to 1 kill ratio. The kill ratio of the U.S. Air Force in Southeast Asia was about 2.5 to 1. We believe that it would be prudent to very seriously consider the changes the fighter pilots recommend.

The bulk of this study is devoted specifically to the issue of finding a better way of selecting men for air-to-air combat. We conclude that there is a way of doing this, and that a program could be instituted which could select men at entry into the military who would prove to be effective air-to-air pilots. It is clear that there are large individual differences in performance which are significant even when comparable equipment is used. The combat effective pilots will demonstrate their effectiveness, during peacetime, in air combat maneuvering range engagements. Furthermore, we believe it is possible for these men to have the motivational characteristics of men who will fight effectively in actual combat.

To do this job properly, however, will take about five years of rigorous work, and cost about as much as a single modern fighter aircraft.

Figure 1.1-1 shows the paradigm for an air-to-air combat effectiveness selection program. The following phases were completed in this study:

a. An extensive and comprehensive job analysis of the fighter pilot using information obtained from validity studies, interviews, and questionnaires.

b. The development of testable trait hypotheses covering 12 content domains.

c. A cost effectiveness analysis of selection tools for testing these trait hypotheses.

d. An evaluation of the reliability of measures in simulators and in air combat maneuvering ranges/instrumentations for the development of peacetime criteria.

e. A review of aviation combat research for the development of combat criteria.

Additionally, programs were outlined for the execution of the peacetime and combat validation phases.

Working from this paradigm, we generated the recommendations shown in Figure 1.1-2. The principal work elements of this ARPA funded study focused on the identification of those critical characteristics and skills which are thought to characterize the combat effective pilot. In all, five major sources of information were used to generate the integrated profile of the combat effective pilot shown in this figure. This profile is based on our comprehensive and systematic review of World War II, Korean, and Southeast Asian conflict information and deals with the scientific studies of combat aviation and combat infantry for those wars. The U.S. military aviation selection research from World War II to the present time was reviewed. This literature, which focuses upon characteristics and critical skills which predict success in flight training, has been used as a source of hypothesis generation because, by implication, these factors may be related to combat effectiveness. We also reviewed the German and Japanese World War II aviation selection research programs as well as the current Israeli program. Our final source of information came from 373 questionnaires which were returned to us by fighter pilots. Significantly, 280 of these returns are either from ace aviators or aviators with MIG kills in Southeast Asia.

FIGURE 1.1-1 PARADIGM FOR AN AIR-TO-AIR COMBAT EFFECTIVENESS SELECTION PROGRAM

9 – 1136

SCIENTIFIC STUDIES OF COMBAT AVIATION

SCIENTIFIC STUDIES OF COMBAT INFANTRY

U.S. MILITARY AVIATION SELECTION RESEARCH

FOREIGN MILITARY AVIATION SELECTION PROGRAMS

INPUTS FROM AMERICAN AVIATORS AND ACES

INTEGRATED PROFILE OF THE COMBAT EFFECTIVE FIGHTER PILOT

DOMAIN	NUMBER OF FACTORS
MEDICAL/PHYSIOLOGICAL	2
APTITUDES	7
DECISION MAKING	5
SENSORY-MOTOR ABILITIES	5
AVIATOR SKILLS/ KNOWLEDGES/TASKS	4
PERSONALITY	5
PERSONALITY – LEADERSHIP	2
MOTIVATION	3
REACTIONS TO STRESS	4
RISK TAKING	1
SOCIAL FACTORS	3
BIOGRAPHICAL DATA	4
TOTAL	45

OF THE 45 FACTORS MAKING UP THE PROFILE OF THE COMBAT EFFECTIVE AIR-TO-AIR FIGHTER PILOT...

8 ARE CURRENTLY ADEQUATELY TESTED FOR BY U.S.A.F. ENTRY SELECTION DEVICES, THEY ARE...
- PHYSICAL HEALTH
- NON PILOT COMPOSITES
- INTELLIGENCE
- NUMERICAL SKILLS
- VERBAL SKILLS
- MECHANICAL SKILLS
- MENTAL HEALTH
- ACADEMIC HISTORY

2 ADDITIONAL FACTORS (MILITARY HISTORY AND MILITARY RANK) ARE RECORDS DEVELOPED DURING THE PILOT'S CAREER.

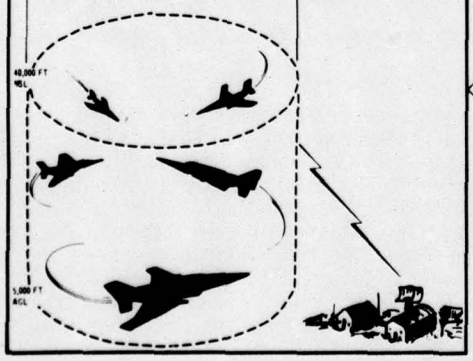
2 OTHER FACTORS (QUALITY OF COMBAT DECISIONS AND COMBAT FLIGHT SKILLS) ARE MOST APPROPRIATELY TESTED AFTER SOME PILOT TRAINING.

33 FACTORS ARE NOT ADEQUATELY TESTED FOR. A PROGRAM IS REQUIRED TO IDENTIFY OR DEVELOP APPROPRIATE SELECTION TESTS FOR THESE FACTORS AND RELATE TEST SCORES ON THESE FACTORS TO PILOT PERFORMANCE IN ACMRs AND IN COMBAT.

AIR COMBAT EFFECTIVENESS STUDY (ACES) PROGRAM

ACES PILOT AIR COMBAT MANEUVERING RANGE PERFORMANCE ASSESSMENT PROGRAM

OPERATIONALLY DEFINED, QUANTITATIVELY MEASURED ASSESSMENT OF THE PILOTS AIR-TO-AIR COMBAT EFFECTIVENESS



ACES SELECTION TEST PROGRAM

SITUATIONAL TESTS AND RATINGS BY PEERS AND OTHERS	SMALL APPARATUS AND COMBAT JOB SAMPLE TESTS	PAPER-AND-PENCIL SELECTION TESTS
• AGGRESSIVENESS • SELF CONFIDENCE • COURAGE • RESPONSIBILITY FOR MEN IN COMBAT • PHYSICAL AND COMBAT LEADERSHIP • DETERMINATION/DESIRE • SELF DISCIPLINE • PERFORMANCE UNDER STRESS • EMOTIONAL CONTROL • ABILITY TO WITHSTAND PSYCHOLOGICAL STRESS • ANXIETY TOLERANCE • WILLINGNESS TO TAKE CALCULATED RISKS • TEAMWORK • SOCIABILITY • INTERPERSONAL RATING	• ABILITY TO WITHSTAND PHYSIOLOGICAL STRESS • FLIGHT APTITUDE (GENERAL AND COMBAT) • SELECTIVE ATTENTION • DECISION TIME • ALERTNESS • INTEGRATIVE DECISIONS • VISUAL PERCEPTION • MOTOR COORDINATION • SPATIAL ORIENTATION • SPATIAL-PERCEPTUAL ABILITY • PERCEPTUAL SPEED • INSTRUMENT READING • AERIAL GUNNERY	• PILOT COMPOSITES • EQUIPMENT KNOWLEDGE • PERSONALITY STYLE • SATISFACTION • LIFE INVENTORY

ACES COMBAT CONTINGENCY VALIDATION PROGRAM

SPECIFICATION OF THE COMBAT DATA REQUIRED TO MAKE A QUANTITATIVE ASSESSMENT OF THE COMBAT EFFECTIVENESS OF INDIVIDUAL PILOTS, UNCONTAMINATED BY SUCH ISSUES AS OPPORTUNITY FOR AIR KILLS.

FIGURE 1.1-2 AIR-TO-AIR COMBAT EFFECTIVENESS FEASIBILITY STUDY

Using the data and inputs from these five sources of information, we generated the integrated profile of the combat effective fighter pilot which you see in Figure 1.1-2. In all, some 45 factors distributed among the 12 major domains can be reasonably hypothesized to be of predictive value in identifying the combat effective air-to-air fighter pilot. As an example, of the 45 factors which can legitimately be supposed to underlie air-to-air fighter pilot combat effectiveness, 35 of them are not adequately tested for by the U.S. Air Force in their entry selection program.[1] Since the methodology either exists or is within our technological grasp for testing the bulk of these hypothesized predictor variables, we believe that a prima facie case has been made for the overall feasibility of such a research program.

The most cost-effective selection test instrument for each particular hypothesized predictor variable is also shown in Figure 1.1-2. In all, five paper-and-pencil selection tests, 13 small apparatus or combat job sample tests, and situational tests and ratings for 15 predictor variables are recommended. In sum, we find that an entry selection program could test for 33 of the 35 hypothesized predictor variables currently not adequately tested for by the U.S. Air Force. This constitutes a principal finding of this study.

As we follow Figure 1.1-2, we see the definition of what we call the Air Combat Effectiveness Study (ACES) program. Here, looking at the right of the figure, we have identified the ACES Selection Test Program which would test for the 33 factors listed. We conceptualize such a selection test program as not being too dissimilar from the current Israeli program, although probably more comprehensive. Such a selection test program could best be conducted at a single site, and candidates would be tested during an estimated seven to ten day period.

Once the selection test scores have been collected, candidate pilots would be free to progress through conventional pilot training to the point where a substantial number of them could be placed in the ACES Pilot Air Combat Maneuvering Range Assessment Program. Here the pilots would fly against specially trained instructor pilots in a series of carefully contrived air combat scenarios. Operationally defined, quantitatively measured assessment scores would be generated as a measure of each pilot's combat effectiveness.

Once this phase of the peacetime program is completed, the pilot's combat effectiveness scores would be correlated with the ACES Selection Test Program Scores, and the determination made concerning the predictive power of the established ACES Selection Test Program. If, upon analysis, adequate correlations exist between some of the candidate pilot's selection test scores and his performance during dissimilar air combat testing, then there will exist, during peacetime, a way of selecting pilots who will perform adequately in the necessary condition for combat success. Combined with appropriately small selection ratios, the probability of picking combat effective pilots will be greatly enhanced.

Finally, we have prepared an ACES Combat Contingency Validation Plan, for ultimately we wish to relate the pilot's scores in both the ACES Selection Test Program and the ACES Pilot Air Combat Maneuvering Range Performance Assessment Program with performance in actual combat. The combat contingency

---

[1] In several places in this report, emphasis has been placed upon the Air Force fighter pilot community. In the course of this study, active attempts were made to extract information about and draw conclusions appropriate to both Air Force and Naval aviation programs. Generally, this has been done, but for multiple reasons the document is oriented toward the Air Force community:

1) The Air Force community has performed more research pertinent to the questions raised in the present report, particularly with respect to the objective assessment of air-to-air combat effectiveness.

(2) The Air Force is specifically charged with the air superiority mission.

(3) When the present research team sought permission to review Air Force and Navy entry level pilot selection instruments, Air Force officials afforded us an opportunity to review Air Force selection instruments, specifically the AFOQT.

validation plan includes a specification of the combat data required to make a quantitative assessment of the combat effectiveness of individual pilots, uncontaminated by such issues as opportunity.

While such an overall program is admittedly ambitious, it is, in our opinion, quite feasible and is potentially a very high payoff program. The nature and size of the effort required to accomplish this job is such that it will clearly require high level endorsement and sponsorship.

The ACES Combat Contingency Validation Program which we have sketched out here is clearly provisional. However, it does supply a usable departure point for a more carefully contrived plan. Air Force efforts, both in World War II and, particularly, Korea, were "reflex actions." In spite of this, the products coming from both World War II, and particularly the Korean conflict, were excellently conceived and executed. Indeed, they form a large basis of what we can say factually about the factors contributing to air combat effectiveness. However, the researchers, through no real fault of their own, had only very limited relevant information on the pilots prior to their entry into combat.

Contingency planning is a military fact of life which, though routinely used for manpower planning, has not been applied to the validation of pilot selection instruments. The ACES program would permit improvement in our air-to-air forces while placing us in a position to collect data during a military encounter, should such an occurrence eventuate. The goal is simply to be prepared with a contingency plan.

If the ACES program recommended in this report is implemented, research scientists will be armed with selection test scores for virtually all of the dimensions presumed to underlie combat effectiveness. Armed with these test scores and an effectively executed combat data acquisition validation program, the military aviation research community will, for the first time in history, be able to specify a definitive profile of the ace fighter pilot.

1.2 INTRODUCTION, RATIONALE AND SCOPE

This study was initiated and funded by the Defense Advanced Research Projects Agency (ARPA) in response to renewed DoD interest in the overall problem of combat effectiveness across all services. It is a feasibility study that reviews an intriguing question: Is there a way of predicting who will be effective in combat? While this question applies to all combat roles, it is particularly compelling in cases where high cost weapons systems, such as aircraft and tanks, are involved.

For this study, we selected the issue of whether or not fighter pilot effectiveness in the air-to-air role could be predicted. Six reasons prompted our selection of fighter pilot effectiveness: (1) the essentiality of air superiority; (2) the reality that in past wars it has been only the few who were truly combat effective; (3) the fact that the overwhelming preponderance of pilot selection research which has been conducted has been devoted to predicting success in flight training and not to predicting success in combat; (4) that a ready criterion, in terms of number of air kills, was available; (5) the potential usefulness of new tools, particularly air combat maneuvering ranges; and (6) the fact that the McDonnell Douglas Corporation is intimately involved in virtually every aspect of fighter aircraft systems effectiveness.

The degree to which we have achieved the comprehensiveness we sought in this study is due in very large part to the literally hundreds of pilots, researchers, and archivists who have taken their time to help us. We thank them here and acknowledge them in Appendix 1.A. Special thanks is extended to Col. James K. Johnson (Ret.), Chairman of the Board of the American Fighter Aces Association, for his outstanding contribution and cooperation.

1.2.1 The Essentiality of Air Supremacy -

The United States has been able to achieve air superiority in three uniquely different kinds of wars. Senior military analysts fear that we may be lulled into complacency. A quote from an article by General B. K. Holloway (1968) serves to underscore the fundamental importance of air supremacy as well as to warn us not to take it for granted.

> "Twenty-six million living Americans are veterans of military service, and most of them have served in wartime. How many of these 26 million ever had to face an enemy who held air superiority?...
>
> "In all, probably no more than one out of 150, for after February 1943 the U.S. and our allies had undisputed air superiority in the Mediterranean and Western Europe; after August of 1943 we had it in the Pacific...
>
> "In Korea we won air superiority twice - from the North Korean Air Force in the first two months of that war, and again from the Chinese Air Force after November 1950. In South Vietnam, our air superiority has come by default. In North Vietnam it has yet to be seriously challenged. [This article was written in 1968.]
>
> "A generation of American fighting men has almost forgotten what it is like not to have air superiority - what it is like to lose mobility except by night; to be cut off from supplies and reinforcements; to be constantly under the watchful eye of enemy reconnaissance aircraft; to be always vulnerable to strafing and bombing attacks; to see one's fighters and bombers burn on their hardstands; to be outnumbered, outgunned, and outmaneuvered in the air." (pp. 3-4)

Today, the need for combat effectiveness is more pressing than ever before. It is unlikely that in our next war we will enjoy the advantages that we had during World War II. We live in an age of strategic parity. In our next war it is unlikely that we will enjoy numerical superiority over our enemies. Critical battles may well have to be fought before we can bring our industrial might to bear.

In today's arena of air superiority, the need for combat effectiveness is all too obvious. We live in a time when we will be able to field only a relatively small number of very expensive air superiority fighters. In the words of General Dixon (1975), the Commanding General of the Tactical Air Command:

> "We [USAF] must offset our numerical inferiority with technology expressed in a higher kill ratio... It is imperative...to increase to

> the utmost the combat readiness and effectiveness of the command..." (In Ulsamer, 1975, pp. 32, 28)

The essentiality of air superiority is currently widely recognized within the military/industrial community and is evidenced in advanced aircraft and avionics design, tests of air combat tactics and missile design within the joint Air Force/Navy ACEVAL-AIMVAL program, the triservice combat readiness Red Flag Program,[1] and the Air Force and Navy air combat maneuvering range training programs employing dissimilar "aggressor" aircraft. A complementary area of research lies in the area of selecting pilots for air-to-air combat effectiveness.

This study is concerned with identifying the attributes which are associated with the successful air combat pilot, and with the feasibility of establishing a pilot selection program aimed at identifying candidate pilots who will be combat effective.

1.2.2 The Precedent for the Study of Combat Effectiveness - A clear precedent exists for the scientific study of the factors which make men fight. In World War II this mandate was issued by General George C. Marshall (Stouffer, Lumsdaine, Lumsdaine, Williams, Smith, Janis, Star, and Cottrell, 1949). The very finest teams of research scientists were assembled and the results were a variety of studies published shortly after the war; The American Soldier (Stouffer, et al, 1949) being representative for combat infantry, while the USAAF Aviation Psychology Program (e.g., Flanagan, 1948) and the Navy's study of 2500 combat Navy pilots entitled, "The Combat Criterion" (Jenkins, Ewart, and Carroll, 1950), constituted the major efforts for combat aviation.

Continuation of this precedent can be seen for the Korean War in the Army's "Fighter" series of studies (Egbert, Meeland, Cline, Forgy, Spickler, and Brown, 1957) which attempted to characterize the factors which were associated with infantrymen that were fighters and infantrymen who would not fight. The Air Force, keenly aware that a handful of their pilots were doing most of the killing, directed the Air Research and Development Command to study the characteristics of Korean War pilots and, if possible, develop a profile of the ace (Strawbridge and Kahn, 1955; Torrance, Rush, Kohn, and Doughty, 1957).

For the war in Southeast Asia the Red Baron reports (1973, 1974) which examine the air war during that time frame, continued the precedent of the scientific study of combat effectiveness. From these studies and other sources, it is possible to build a general profile of what makes a combat effective soldier or airman. First, however, let's look at some of the realities of combat effectiveness.

1.2.3 The Realities of Combat Effectiveness - S. L. A. Marshall, a World War I combat infantry officer and military historian, had an unparalleled opportunity to investigate the combat effectiveness of American Infantrymen of World War II. In all, Marshall interviewed some 400 companies of infantry both in Europe and the South Pacific. His book, Men against Fire (1947) published shortly after the war, is a thoughtful and emotional statement of his findings and opinions.

Marshall's most dramatic revelation was that in any given engagement about 80% of American infantrymen did not fire their weapons effectively. This is astonishing indeed, but so are the combat effectiveness records of fighter pilots.

The German fighter pilots of World War II, some of whom flew "from the first to the last," set some truly remarkable kill records. Their top ten pilots scored a staggering total of 2568 kills among them (Weiss, 1966). According to Hans Ring, the German fighter pilot historian, a mere 300 German pilots destroyed 30,000 Russian aircraft (Sims, 1967). Most American pilots fought a much "shorter" war but here, too, a wide spread of scores is to be found.

---

[1]See Glossary in Section 9.1

According to official Eighth Air Force records of the 5000 fighter pilots who flew against the Germans during 1943-1945, only a relative handful became aces. Of the 5000, only 261 (or 5.2 percent) achieved this goal.[2] However, this small group of men accounted for 40 percent of the total 5284.5 German planes destroyed by the Eighth Air Force fighter pilots during that period; thus, five percent claimed forty percent of the kills.

The Eighth Air Force fighter pilot kills record shown in Figure 1.2-1 illustrates the enormous difference in pilot kills. Among those with air-to-air kills, over 1000 pilots (47.8 percent) had 1/2 to 1 kill, while 57 pilots (2.6 percent) had more than 10 kills.

History repeated itself in the Korean War, for again it was found that a small percentage of Air Force pilots were accounting for the lion's share of the kills. A summary of the MIG-15 kill statistics for 800 USAF F-86 pilots in the Korean War is shown in Figure 1.2-2. Here again, we see the largest group of pilots recording no kills (53.5 percent) while a small group of 38 pilots (4.8 percent) were able to become aces. Importantly, each of the F-86 pilots is known to have had at least 25 counterair missions and, therefore, presumably, a fair chance for a kill (Torrance, et al, 1957). Clearly, the handful of aces are making an over-

[2]These particular records include credits given to pilots for the destruction of enemy aircraft on the ground. Examination of the air-to-air kills for the same group evidences the same trend for markedly superior performance for only a handful of pilots (see Section 3.1).

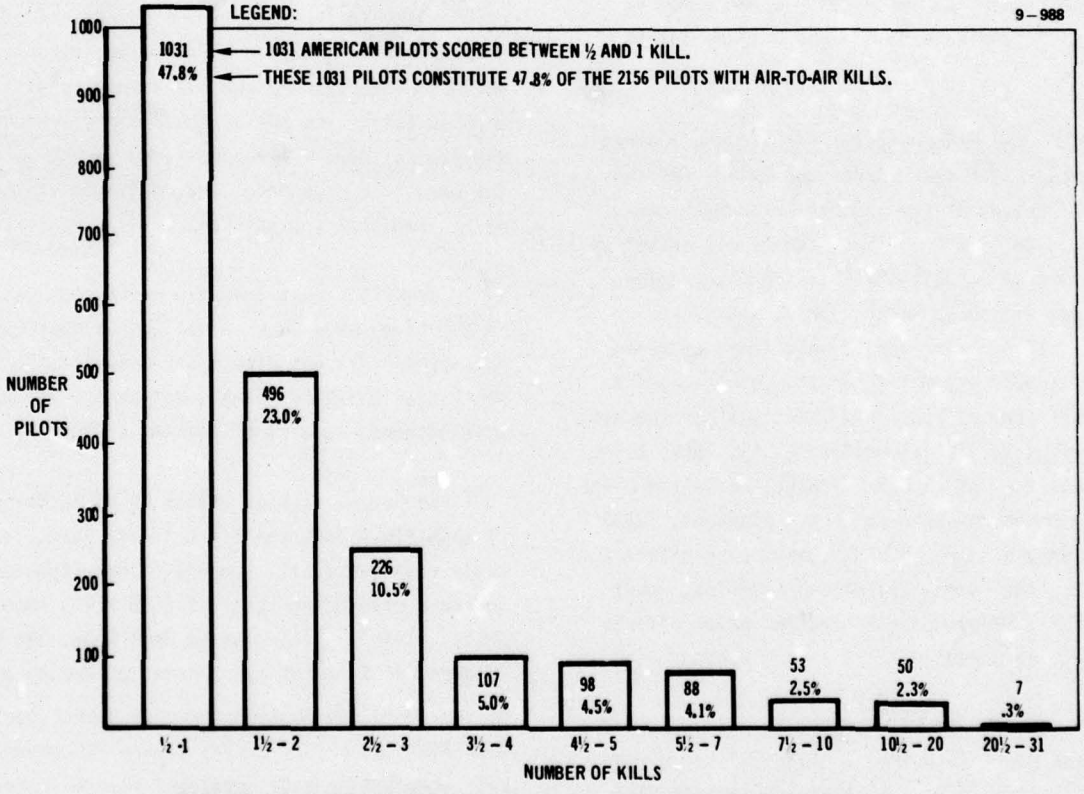


FIGURE 1.2-1 THIS FIGURE SHOWS THE NUMBER OF EIGHTH AIR FORCE PILOTS WITH AIR-TO-AIR KILLS RANGING FROM 1/2 KILL TO 31 KILLS AGAINST THE GERMANS IN WORLD WAR II. (From Final Report of Assessed Fighter Claims Against Enemy Aircraft, August 1942 - April 1945; Published September, 1945)

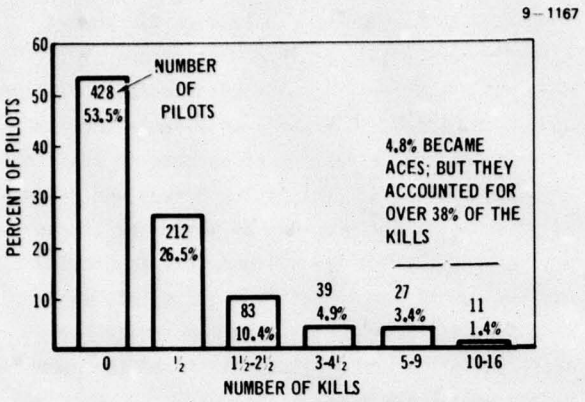


FIGURE 1.2-2 THIS FIGURE SHOWS KOREAN WAR MIG-15 KILLS FOR 800 USAF F-86 PILOTS EACH OF WHOM HAD AT LEAST 25 COUNTER-AIR MISSIONS (Drawn from Statistical Kill Summary Shown in Torrance, ET AL, 1957)

whelming contribution to air-to-air kills; air supremacy.

The issue of opportunity for air kills clouds the analysis of kills. However, even when one examines the kill records of pilots who had a proven opportunity, we still see a small percentage of men (10 percent) getting the lion's share of the kills.[3]

Two outspoken critics of identifying combat effective pilots by their kill records per se are Strawbridge and Kahn (1955). Their study is highly professional and their point well taken. Kills per opportunity[4] would certainly be an admirable "scientific" measure of pilot combat effectiveness. Using the argument that "combat effectiveness can be evaluated only for those pilots who had sufficient contact with the enemy," they performed an exhaustive analysis of the operational flight records of 520 pilots of the Fourth Fighter Interceptor Wing who flew combat in Korea from which they selected 69 pilots who, they felt, had sufficient opportunity for MIG kills. Each of the 69 pilots they selected had 15 or more encounters with the enemy, while serving as an element leader. They concluded:

> "Among those pilots who had sufficient contact with the enemy (15 or more encounters), considerable variability in effectiveness is noted. Some pilots were able to convert 70-80 percent of their encounters with the enemy into firing passes, and 60-70 percent of their firing passes resulted in kills. Others converted as few as 15 percent of their encounters with the enemy into firing passes, and in some cases as few as 0-10 percent of the firing passes were converted to kills." (Strawbridge and Kahn, 1955, p.71)

This study by Strawbridge and Kahn (1955) deserves a wider audience, for it demonstrates what we know intuitively - that some pilots are, in fact, superior to other pilots in air-to-air combat. This study, and others conducted during the Korean period, are particularly important because the issue of opportunity dominates the air war analysis of Southeast Asia. While the air war in Southeast Asia lasted for a long period of time and involved a large number of pilots, it has often been characterized as "seven one-year wars."

Many pilots who flew large numbers of combat missions in Southeast Asia probably never encountered enemy fighter aircraft. The total number of air kills in air-to-air combat engagements by both Air Force and Navy during the entire war in Southeast Asia totaled only about 200. Because of this issue of opportunity, most of the pilots from the Southeast Asian conflict who we questioned simply did not believe that a pilot with one air kill significantly stood above other pilots; the other pilots, they believe, may simply not have had a chance for a kill.

One area where luck plays an undeniable, and perhaps overwhelming role, is in a pilot's first few encounters. In a well known article, Weiss (1966) has presented data from three large air combat units which portray a very grim picture of a fledgling pilot's chances for surviving his first

---

[3]Reexamination of Figure 1.2-2 and ignoring the group of pilots with no kills, still reveals dramatic differences in pilot kill records.

[4]Of course this won't change the popular literature on ace pilots. If we were to use kills per sortie then we would all know the name of the German pilot, Lt. Guenther Scheel, who scores 71 kills in 70 missions and not Erich Hartmann with his 352 kills in 826 encounters during 1405 missions (Constable and Toliver, 1968).

decisive combat engagement. Weiss' data show that a pilot's chances for winning decisive aerial engagements improves dramatically over his first few engagements. Significantly, those pilots who survive their first few decisive encounters then evidence a remarkably high probability of winning subsequent decisive encounters; greater than a .98 chance of survival.[5]

Two important points should be made with regard to these concepts. If we send pilots to combat without adequate specialized air-to-air combat training[6] against an enemy with good fliers, then we must anticipate high attrition, poor combat effectiveness, or both, to occur. If Weiss' analysis of the air war of World War II is prophetic of future conflicts, and if we can select and train our pilots to high air-to-air readiness, then we can expect to sustain high kill ratios against any opponent without an equally effective selection, training, and pilot management system.

1.2.4 Overview of this Report - The body of this report consists of Sections 2 through 7 shown in overview in Figure 1.2-3. Section 9 includes a glossary of terms and acronyms which might be quite valuable to the reader not familiar with terms commonly used in the fighter pilot community. In Section 2 we discuss the pilots' responses to the nine major policy issues shown in Figure 1.2-3. Pilots' attitudes toward the universally assignable pilot are, for the most part, very hostile. Also, the majority of pilots feel that a pilot's performance in air combat maneuvering range engagements will be indicative of his performance in combat, and that the majority of pilots feel that selection standards should be more rigorous for the identification of air-to-air fighter pilots.

Section 3, which focuses on identifying the attributes, i.e., the characteristics and critical skills of the combat effective, is introduced by a subsection dealing with the technical issues involved in any appraisal of air combat effectiveness. Specifically, we briefly review the issues of opportunity, chance, luck, and survival of the fittest/experience, as they relate to providing a context within which we can examine air combat effectiveness data. Section 3 comprehensively examines the scientific studies of combat aviation and combat infantry, as well as pilot selection studies for the prediction of success in training. In addition, a treatment of the German and Japanese aviation selection programs of World War II, as well as the current Israeli program, is provided. Finally, we review inputs from 373 pilots who responded to the questionnaire concerning the characteristics and critical skills of the combat effective fighter pilot.

All of these sources of information permit us, in Section 4, to develop an integrated profile of the combat effective fighter pilot. The list which you see in Figure 1.2-3 shows the 12 domains made up of 45 factors which can reasonably be supposed to underlie air-to-air combat effectiveness.

As we have already suggested in the Executive Summary, paper-and-pencil testing, particularly in the Life Inventory area, has some potential as an effective selection device for some of the factors. In Section 5 we report on our preliminary efforts to develop and "validate" an instrument of this type. A preliminary analysis of the Life Inventory responses of nearly 400 pilots is presented.

The data developed in Section 6 reflect the fact that many of the factors underlying air combat effectiveness may be tested in an air combat job sample approach to the problem. Consequently, during the course of this study we examined representative simulators within the community so that we could understand many of the complex issues involved in the development of an adequate job sample approach to selecting for combat effectiveness.

---

[5]This makes intuitive sense and "explains" how some pilots could achieve hundreds of kills (see Section 3.1).

[6]In this regard, note that the U.S. Navy kill ratio in Southeast Asia jumped from 2.5 to 1, to 12.5 to 1, following initiation of their Top Gun school which trained pilots in air combat maneuvering range engagements (deLeon, 1977; see Section 3.1).

We also examined air combat maneuvering range/instrumentation facilities for the development of peacetime criteria of combat effectiveness.

In Section 7 of this document we perform a rough cost effectiveness evaluation of testing instruments which could be used to discriminate among pilots across 33 of the factors presumed to be of predicitive value. From this we developed a recommended Air Combat Effectiveness Study (ACES) program which, in overview, provides a description of the multi-year selection test program using pilot performance in air combat maneuvering ranges as a peacetime test bed. Lastly, we identify the combat data requirements associated with a combat contingency validation. A final summary of these sections may be found in Section 8.

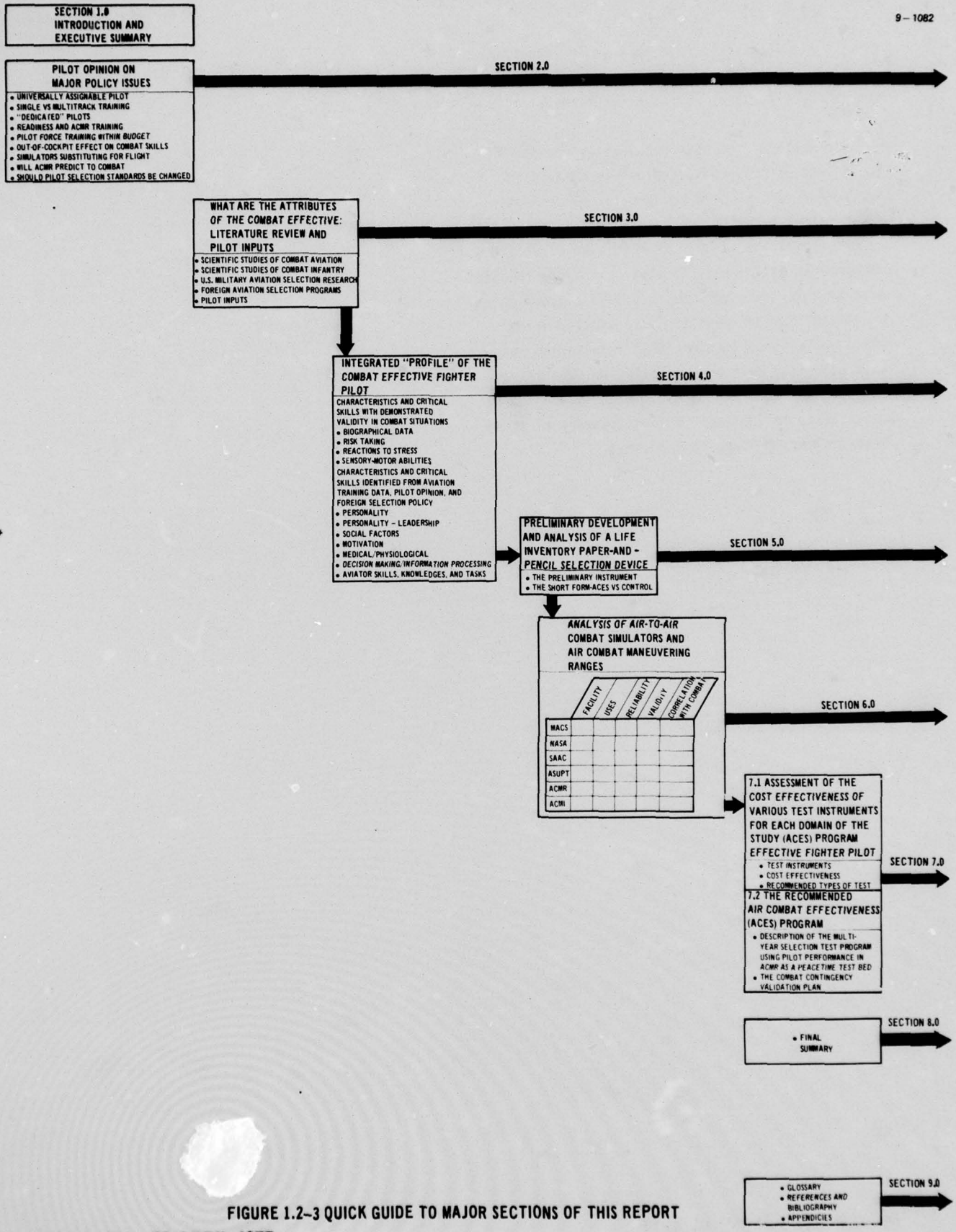


FIGURE 1.2-3 QUICK GUIDE TO MAJOR SECTIONS OF THIS REPORT

2.0 PILOT OPINION ON MAJOR POLICY ISSUES

During the initial stage of this study effort, two members of the research team - one a behavioral scientist, the other a combat aviator - visited with some 15 organizations and talked with approximately 60 researchers and pilots (see Appendix 1-A). The recurrent theme in these visits was that there are some obvious ways of improving air-to-air combat effectiveness, but that many of them would be very difficult to implement since they are not in accordance with existing Air Force policy. It became obvious that one of the more useful things we could accomplish in the course of this study was the documentation of pilot attitudes on significant "policy" issues. Our rationale was that if a strong consensus was found, and that if these attitudes could be brought to the attention of senior Air Force policy makers, then positive change might be forthcoming.

Accordingly, we distributed 735 questionnaires to the groups shown in Figure 2.0-1. In all, 373 pilots responded for a surprising 51% response rate (typically, questionnaire response rates range from 20 to 25%). Significantly, about two-thirds of the pilot respondents were from the American Fighter Aces Association, each member of which has at least five air combat kills.

9-1155

PILOT ORGANIZATION	NUMBER DISTRIBUTED	NUMBER RETURNED	PERCENT RETURNED
AMERICAN FIGHTER ACES ASSOCIATION	524	257	49
NAVY MIG KILLERS ASSOCIATION	42	22	52
RED RIVER VALLEY FIGHTER PILOTS ASSOCIATION (RIVER RATS)	99	51	51
NATIONAL GUARD PILOTS	40	13	33
ACEVAL-AIMVAL NAVY PILOTS	12	12	100
ACEVAL-AIMVAL AIR FORCE PILOTS	6	6	100
AGGRESSOR SQUADRON AT NELLIS	12	12	100
TOTAL	735	373	51

FIGURE 2.0-1 PILOT ORGANIZATIONS AND RESPONSE FREQUENCIES TO THE PILOT QUESTIONNAIRE USED IN THIS STUDY

This section of our report discusses pilot attitudes concerning the nine policy issues shown in Figure 2.0-2. The percentage of pilots agreeing or disagreeing with specific questions dealing with each of these policy issues and a selected sampling of written responses are presented. The responses typify the positive and negative attitudes of the pilot group concerning each issue.

9-1106

THE UNIVERSALLY ASSIGNABLE PILOT
SINGLE TRACK VS MULTITRACK TRAINING
"DEDICATED" AND "CONTRACT" PILOTS
COMBAT READINESS AND THE ACMR
PILOT FORCE TRAINING WITHIN BUDGET LIMITS
OUT-OF-COCKPIT EFFECTS ON PERFORMANCE
SIMULATORS SUBSTITUTING FOR FLIGHT TIME
WILL ACMR PILOT PERFORMANCE "PREDICT" TO COMBAT
SHOULD FIGHTER PILOT SELECTION STANDARDS BE TOUGHENED

FIGURE 2.0-2 VARIOUS "POLICY" ISSUES IN OUR QUESTIONNAIRE TO PILOTS

2.1 THE UNIVERSALLY ASSIGNABLE PILOT

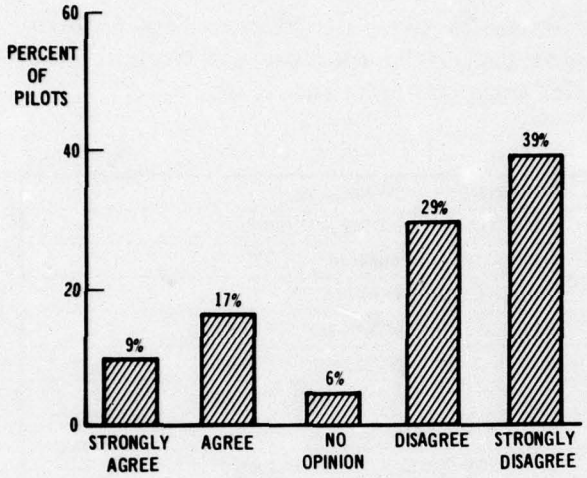
The question which evoked the strongest response was the one concerning the universally assignable pilot. Figure 2.1-1 contains a histogram showing the percent of pilots who either strongly agreed, agreed, had no opinion, disagreed, or strongly disagreed with this concept. Thirty-nine percent of the pilots strongly disagreed with the concept of the universally assignable pilot. An additional 29% of the pilots disagreed with the concept making a total of 68% who opposed it.[1]

The pilot comments shown in Figure 2.1-1 reflect the generalized hostility toward the concept of the universally assignable pilot. Comments from

[1]These percentages and those that will be reported throughout this section are for the entire pilot sample. When one looks at the responses of current pilots (i.e., all groups except the American Fighter Aces Association) the percentages change somewhat. In this case 89% of the pilots either disagreed or strongly disagreed with the concept of the universally assignable pilot.

QUESTION:

THE CURRENT AIR FORCE DOCTRINE AIMS TOWARD THE SELECTION AND BASIC TRAINING OF PILOTS TO THE END THAT NEW GRADUATES CAN BE ASSIGNED TO ANY TYPE AIRCRAFT (THE UNIVERSALLY ASSIGNABLE PILOT CONCEPT). DO YOU AGREE WITH THIS CONCEPT?



SELECTED PILOT RESPONSES FROM MEN WHO DISAGREE OR STRONGLY DISAGREE:

STRONGLY DISAGREE AMERICAN FIGHTER ACE – THE TRANSITION FROM FIGHTER TO BOMBER, TO CARGO ARE EASIEST IN THAT ORDER. I BELIEVE IT TOO COSTLY IN DOLLARS, LOGISTIC AND TRAINING EFFORTS, AND IN SAFETY TO TRY TO MAKE A FIGHTER PILOT OUT OF A BOMBER OR CARGO PILOT – UNLESS THERE IS NO OTHER CHOICE. TO GO FROM FIGHTER TO BOMBER TO CARGO IS RELATIVELY EASY BECAUSE LESS PHYSICAL REQUIREMENTS ARE NEEDED. THE BEST PILOT IS ONE WHO IS SKILLED IN THE AIRCRAFTS HE FLIES AND THE ENVIRONMENT IT IS TO BE FLOWN IN – CONSTANT CHANGES ARE FOOLISH AND COSTLY.

STRONGLY DISAGREE AMERICAN FIGHTER ACE – IN THIS AGE OF SOPHISTICATED ARMAMENTS, WE HAVE LEARNED (USUALLY THE HARD WAY) THAT THERE IS NO SUCH THING AS A UNIVERSAL WEAPONS SYSTEM. WHY SHOULD THE USAF PURSUE A "UNIVERSAL" PILOT CONCEPT?

STRONGLY DISAGREE AMERICAN FIGHTER ACE – A BOMBER PILOT! GEN SPAATZ THOUGHT THIS ONE UP. I HAD A FEW PEOPLE SELECTED AND TRAINED UNDER THIS PRECEPT. SOME WERE OK, MOST WERE UNACCEPTABLE. THREE I COULDN'T EVEN USE.

STRONGLY DISAGREE AGGRESSOR SQD. THE UNIVERSAL PILOT IS A FINE "WHOLE MAN" WHO WILL BE ABLE TO IMPRESS THE POOR DUMB SPECIALIZED S.O.B. WHO IS SHOOTING HIM DOWN WITH THE FACT THAT HE (THE WHOLE MAN) HAS A PH.D. IN MANAGEMENT, HAS COMPLETED AIR COMMAND AND STAFF SCHOOL AND WOULD BE CAPABLE OF FLYING THE C-141 WITH A MINIMUM OF TRAINING, IF IT WEREN'T FOR THE FACT THAT HE WILL BE DEAD IN THE NEXT 30 SECONDS. THE UNIVERSAL PILOT IS THE UNIVERSAL TARGET.

DISAGREE AMERICAN FIGHTER ACE – IN SECONDARY TRAINING AT PENSACOLA, FLORIDA WHEN FLYING AIRCRAFT LARGER THAN TRAINING AIRCRAFT – EVERY PILOT WAS GRANTED A PRIVATE INTERVIEW WITH THE C.O. OF THE SECONDARY TRAINING FACILITY TO AIR HIS REQUEST TO GO INTO "PATROL AIRCRAFT" "SCOUTING AIRCRAFT" OR "CARRIER BASED AIRCRAFT." I PERSONALLY REQUESTED "CARRIER BASED AIRCRAFT" AND WAS GRANTED A TRANSFER TO "CARRIER TRAINING FACILITIES" IN OPE-LOCKE, FLORIDA. I PERSONALLY ENDORSE THE INDIVIDUAL SELECTION OF TYPE AND AREA OF SERVICE RATHER THAN "UNIVERSALLY ASSIGNABLE CONCEPT POLICY."

FOR THE RECORD –
1) I WANTED TO FLY – I APPLIED AND WAS ACCEPTED.
2) I WANTED CARRIER DUTY – AND WAS ACCEPTED.
3) I WANTED TO BE A FIGHTER PILOT.
4) I REQUESTED TO BE A FIGHTER PILOT AND WAS ACCEPTED.
5) I AM SATISFIED WITH MY FIGHTER PILOT RECORDS.

DISAGREE RIVER RAT SCREW THE POOLING OF PILOTS UNDER DILETTANTE TITLES LIKE ("UNIVERSALLY ASSIGNABLE CONCEPT POLICY") – A GOOD FIGHTER PILOT IS NOT UNIVERSALLY ASSIGNABLE – YOU WILL BREAK HIS HEART AND AMBITION TO BE SOMETHING EXCEPTIONAL ACCORDING TO HIS MILITARY FLYING AMBITIONS. DO NOT EVER ADOPT ANY TRAINING PROGRAM EVER ANYWHERE IN ANY SERVICE WHERE INDIVIDUAL PILOT AMBITIONS ARE NOT SENSIBLY REVIEWED!! IN MY JUDGMENT PILOT STUDENT AMBITIONS AS TO TYPE, AREA OF SERVICE AND AIRCRAFT IS A MORALE PRODUCING, COST SAVING PROCEDURE IF HANDLED CORRECTLY.

SELECTED PILOT RESPONSES FROM MEN WHO AGREE OR STRONGLY AGREE:

STRONGLY AGREE AMERICAN FIGHTER ACE – ELIMINATE ALL PILOTS THAT CANNOT BE ASSIGNED, FOR ANY REASON, TO ANY TYPE AIRCRAFT.

AGREE RIVER RAT – IDENTIFY WHAT TYPE OF AIRCRAFT THE INDIVIDUAL WANTS TO FLY AFTER HE SOLOS THE T-38. AT THAT TIME THE PROGRAM CAN START TO BE TAILORED. MORE INSTRUMENTS AND LESS FORMATION FOR THE MULTI-ENGINE PILOTS. MORE INFORMATION, AERO, AND FORMATION AERO FOR THE "FIGHTER PILOTS."

AGREE AMERICAN FIGHTER ACE – I FEEL SAME THAT SOMEWHERE IN THE BASIC PIPELINE, STUDENTS ARE EVALUATED (CONTINUOUSLY) AND GRADED FOR ASSIGNMENT TO TYPE COMMANDS – CHOICE BY STUDENT, TRAINING PERFORMANCE, PEER RATINGS, MUST ALL MAKE UP A PART OF THE FINAL ASSIGNMENT – BUT, ABOVE ALL, A STUDENT MUST.....WANT TO BE A FIGHTER PILOT.

AGREE AMERICAN FIGHTER ACE – BETTER QUALITY SELECTION FROM UPT TO APPROPRIATE CCTS.

AGREE RIVER RAT – BASIC SELECTION AND BASIC TRAINING IN THE UNIVERSALLY ASSIGNABLE PILOT CONCEPT MAKES SENSE, BUT FIGHTER PILOTS SHOULD BE SELECTED AT THE END OF PILOT TRAINING AND ALLOWED TO SPECIALIZE AS FIGHTER PILOTS FROM THEN ON.

FIGURE 2.1-1 PILOT OPINION OF THE CONCEPT OF THE UNIVERSALLY ASSIGNABLE PILOT

pilots who agreed with the concept are also shown. It appears to us that many of the pilots who said they agreed with the concept probably misunderstood the question. In any event, there appears to be absolutely no question that the majority of the pilots not only disagree, but are actually hostile to the concept. The specialized literature dealing with this subject area is also very critical of the concept of the universally assignable pilot. The following remarks are drawn from three recent Air University research reports.

The most recent of these studies was conducted by Cooper, Imaye, Karre, Robertson, Ryan, and Sakahara (1976). In the preface to their study, these authors offer a rather succinct condemnation of the concept of the universally assignable pilot.

> "The realities. . .indicate that the universally assignable concept is a myth. It deserves to be retired to its niche in military history along with the battleship and the horse calvary." (p. iii)

Cooper, et al, (1976) offered several reasons for selection and specialization. These include the training costs and the costs of accidents attributable to misassignment, and the increased force effectiveness which would accrue from specialized assignment. Additionally, the current tendency within the USAF to isolate pilots into specific weapons systems (prompted by decreased training costs and increased proficiency) attests to the need for specialization. Underlying all of these arguments is the assumption that the population of potential pilots is large enough to permit proper selection and that valid criteria for specific pilot jobs can be developed to allow this selection process to take place. The result of this effort is not to produce a universal pilot but to ". . . place the pilot candidate in the weapons system most suited to his particular talents, abilities, and motivations" (Cooper, et al, 1976, p. ii)

Anderson (1972) in his Air University research report entitled, The Tactical Fighter Pilot: Improving Combat Effectiveness, sums up the great need for specialization.

> "In order to obtain the first great need of the Air Force, that is, optimum motivation, skill, and combat capability for tactical fighter forces, tactical fighter pilot training must be reorientated to a dual track or specialized system. Prior to selection for pilot training, individuals should be identified whose physical and psychological makeup, as determined by the appropriate psychological testing, indicates potential fighter pilot capabilities. Individuals so identified should be provided specialized training oriented toward eventual fighter pilot qualification throughout the entire undergraduate course of training." (Anderson, 1972, p. 36)

In an Air University research report, Kyer (1973) views the trend towards specialized missions as underlying a trend towards specialization of pilot training. To quote from his article:

> "The Air Force has recognized that tactical aircraft, with a specialized mission, are required to fill a specific tactical requirement. For example, the A-7, a conventional ground support type aircraft with no nuclear capability and limited air-to-air capability was purchased. The first air superiority fighter specifically designed for the air superiority role since the F-86, the F-15, was initiated. Requirements for a lightweight air superiority fighter were drafted and the A-7 and A-10 prototypes have been produced to fill the necessity of a relatively inexpensive ground attack aircraft. With the change in Air Force policy from the multi-mission aircraft to the specialized aircraft, will Air Force training policy also change? The writer, [Kyer] believes that a complete change in aircrew selection and training is mandatory in order to effectively execute the Air Force mission. Only those aircrews with the proper skills and aptitudes should be selected for air superiority training programs." (Kyer, 1973, pp. 12-13)

To summarize, three different Air University research reports that recently dealt with the universally assignable pilot have for a variety of reasons recommended a return to specialized pilot training. These arguments, when combined with the negativism expressed by the pilots that were questioned concerning the concept of the universally assignable pilot, strongly indicate that the issue should be reviewed at the highest levels of U.S. military decision making.

2.2 SINGLE VERSUS MULTI-TRACK TRAINING

The pilot opinion responses concerning the relative merits of single versus multi-track training are shown in Figure 2.2-1. Multi-track training is, of course, the application of the conceptual antithesis of the universally assignable pilot. As such, we expected answers which would mesh with the answers to the universally assignable pilot question. By phrasing the present question with the training aspects separated from the operational implications of the concept, different responses might be expected. Fully 61% of the pilots strongly agreed or agreed that a multi-track system would be superior to the current Air Force undergraduate pilot training single track approach.[2] Twenty-one percent of the pilots disagreed or strongly disagreed; 18% had no opinion.

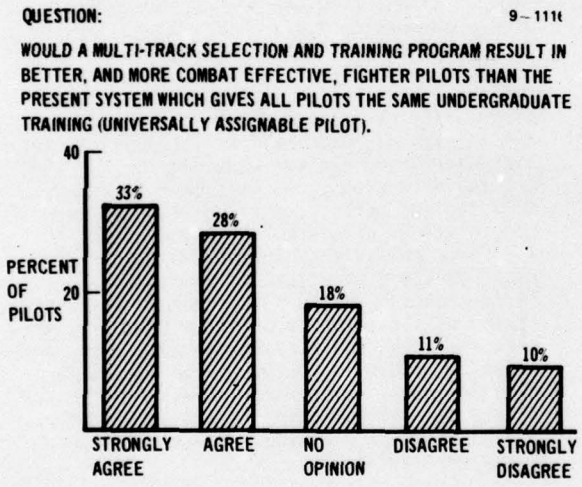


FIGURE 2.2-1 PILOT OPINION CONCERNING A MULTI-TRACK TRAINING SYSTEM

A large amount of Air Force funded work was conducted during 1969-70, on the definition of future undergraduate pilot training.[3] These studies were comprehensive, producing a large package of documentation addressing the many critical issues in an enterprise designed to tailor a pilot training program to meet the operational mission requirements of the 1975 to 1990 time frame. Significantly, each of the contractors recommended that one form or another of a multitrack program be instituted.

To quote from the Cooper, et al, (1976) summary of the Northrop Future Undergraduate Pilot Training Study (1971):

> "The study proposed a primary phase followed by one of three different basic phases: a generalized basic phase much like the present; a dual track basic phase of fighter and bomber/transport; or a four track basic phase of air superiority fighter, attack fighter, bomber, and transport. Of primary interest is the fact that the assignment problems of today are going to remain a major factor in the future. Should one of the track systems be instituted, two major implications are evident. The selection process to the FAR (Fighter/Attack/Reconnaissance) or TTB (Transports/Tanker/Bomber) track will have to be made even earlier than at present; and to make a track system both effective and efficient, the selection process must be more accurate." (p.59)

Thus, the implementation of a multi-track program returns to the underlying problem of effective, efficient and accurate pilot selection.

2.3 DEDICATED AND CONTRACT PILOTS

One approach that is often suggested for improving air-to-air pilot effectiveness is to have certain pilots dedicated specifically to that mission. Figure 2.3-1 shows the pilots' attitudes regarding this concept. Fully 72% of the pilots agreed or strongly agreed that air-to-air pilots should be dedicated specifically to that mission; 22% disagreed or strongly disagreed with the concept. The written pilot responses shown in Figure 2.3-1 characterize the pilots' positive and negative attitudes toward this concept.

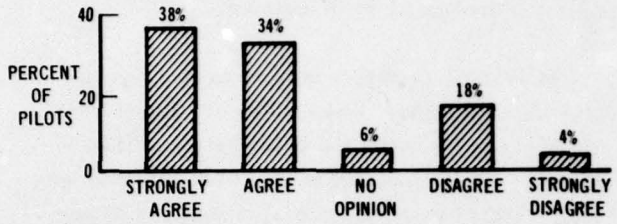
Less than 50% of all the pilots endorsed (i.e., agreed or strongly agreed) the concept of "the contract pilot" (see Figure 2.3-1). On the other hand, 64% of the current pilots agreed or strongly agreed, while pointing out that career limitations were improper.

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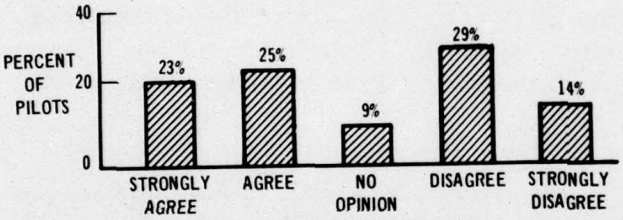
[2] The sample of current pilots (i.e., excluding inputs from the American Fighter Aces Association) were even more in agreement; 79% of them agreed or strongly agreed.

[3] The reader can find the bibliographical references for these recent studies, along with a number of related studies, in the bibliography section on Pilot Training Requirements and Techniques (see Section 9).

STATEMENT:
OUR MODERN HIGH PERFORMANCE AIR-TO-AIR COMBAT AIRCRAFT SHOULD BE PILOTED BY PILOTS WHO ARE DEDICATED TO THAT MISSION (I.E., NO STAFF ASSIGNMENTS).



QUESTION:
SUPPOSE A SPECIAL CATEGORY OF CAREER AIR-TO-AIR PILOT WAS DESIGNATED. ONLY HIGHLY SELECTED VOLUNTEERS WOULD BE CHOSEN ON A CONTRACT BASIS. THEY WOULD RECEIVE MORE INTENSIVE AIR-TO-AIR TRAINING, WOULD HAVE NO OTHER DUTIES AND WOULD RECEIVE A NUMBER OF SPECIAL BENEFITS. CAREER ADVANCEMENT WOULD, HOWEVER, BE LIMITED. WHAT IS YOUR OPINION OF THIS CONCEPT?



SELECTED, PILOT RESPONSES FROM MEN WHO DISAGREE OR STRONGLY DISAGREE

DISAGREE AMERICAN FIGHTER ACE – BELIEVE THAT AVERAGE WELL-TRAINED FIGHTER PILOT IS A GOOD POTENTIAL AIR-AIR COMBAT CANDIDATE. I VOTE FOR QUANTITY AND STANDARDIZATION. A CORPS OF "ELITE" AIR-AIR PILOTS WOULD BE A PAIN-IN-THE-ASS TO THE REMAINDER OF THE FIGHTER FORCE AND PROBABLY WOULD DO NO BETTER IN COMBAT THAN THEIR LESS "ELITE" CONTEMPORARIES PROVIDED EQUAL OPPORTUNITIES ARE PRESENTED.

DISAGREE RIVER RAT – THOUGH SPECIAL CATEGORY, THESE SELECTED PILOTS SHOULD HAVE OTHER DUTIES (COMPATIBLE WITH FLYING/SIMULATOR TRAINING) AND SHOULD HAVE UNLIMITED OPPORTUNITY FOR PROGRESSION.

DISAGREE AMERICAN FIGHTER ACE – I DON'T LIKE IT. A GOOD FIGHTER PILOT SHOULD BE (AND THE BEST ONES ARE) WELL ROUNDED IN MILITARY REQUIREMENTS OTHER THAN A "FAST DRAW" – A GOOD FIGHTER PILOT WOULD NOT ACCEPT THESE NARROW LIMITATIONS THAT DENY A BROADER KNOWLEDGE, GREATER UNDERSTANDING. THE OPPORTUNITY TO GROW – PRIDE AND HEART WOULD BE DOWNPLAYED.

SELECTED PILOT RESPONSES FROM WHO AGREE OR STRONGLY AGREE

STRONGLY AGREE NAVY MIG KILLER – ABSOLUTELY AGREE, AND THOUGH I 'M NOW 31 AND HAVE BEEN OUT OF F-4s FOR FOUR YEARS, I'D BE THE FIRST TO SIGN UP....LET ME KNOW – IT'S A GREAT CONCEPT!!!

STRONGLY AGREE AGGRESSOR SQUADRON – IF YOU'RE SERIOUS ABOUT FLYING AIR-TO-AIR – ADVANCEMENT ISN'T IMPORTANT.

STRONGLY AGREE NAVY MIG FIGHTER – SOME OF THE BEST FIGHTER PILOTS I KNOW DON'T CARE TO BE OF FLAG RANK OR CAPTAIN – ALL THEY WANT TO DO IS FLY. WHEN THEY ARE TOLD THAT THEY MUST DO A SHIP'S COMPANY TOUR FOR THE GOOD OF THEIR CAREER, MANY GET OUT – LIKE I DID.

STRONGLY AGREE RIVER RAT – I HAVE SAID THE SAME THING MANY TIMES. I WOULD BE MORE THAN HAPPY TO SPEND 20 YEARS FLYING FIGHTERS AND NOT EXPECT TO MAKE RANK HIGHER THAN O-3.

STRONGLY AGREE RIVER RAT – CAREER ADVANCEMENT SHOULD NOT BE LIMITED – IF ANYTHING, THESE INDIVIDUALS SHOULD BE CONSIDERED AN "ELITE" AND PROMOTED AHEAD OF THEIR CONTEMPORARIES.

AGREE AIR NATIONAL GUARD – I MILDLY OBJECT TO THE CONCEPT OF THE ELITE TRAINED PROFESSIONAL KILLER BUT IT WOULD BE DEADLY EFFECTIVE IN COMBAT.

STRONGLY AGREE AMERICAN FIGHTER ACE – IF THE ENEMY HAS A STRONG AIR-TO-AIR CAPABILITY THIS IS ESSENTIAL. A SUPER AIR-TO-AIR CAPABILITY WOULD BE A BIG DETERRENT FOR A POTENTIAL AGGRESSOR. HE WOULD EITHER HAVE TO DILUTE HIS BOMBARDMENT CAPABILITY OR ACCEPT LARGER LOSSES. WE WOULD GAIN EITHER WAY.

AGREE AMERICAN FIGHTER ACE – MANY OF YOUR BEST FIGHTER PILOTS (WORLD WAR II) WERE NOT CAREER ORIENTED PEOPLE.

AGREE AMERICAN FIGHTER ACE – I HAVE ALWAYS FELT WE WOULD HAVE BEEN AHEAD IN A COMBAT SITUATION, WWI, WWII AND KOREA, HAD WE CONCENTRATED ON PROFESSIONAL PILOTS RATHER THAN OFFICERS. WE LOST A LOT OF GOOD FIGHTER PILOTS BECAUSE THEY WERE NOT GOOD OFFICER MATERIAL.

STRONGLY AGREE ACEVAL – AIMVAL – WE HAVE PROVEN TIME AND TIME AGAIN THAT A STAFF OFFICER IS NOT A LINE FIGHTER PILOT AND CANNOT EVER BE.....BUT WHY LIMIT CAREER ADVANCEMENT? THE OPTIONS, HOWEVER, AS SUGGESTED, SHOULD BE CLEAR, WITH NO "HAZY" CRITERIA FOR ADVANCED PROMOTION AS IS NOW. I BELIEVE IN AN ELITE CORPS – DEDICATED WARRIORS "PATTON" AIR-TO-AIR PILOT CADRE IS THE ANSWER.

FIGURE 2.3-1 PILOT OPINION CONCERNING DEDICATING PILOTS TO CERTAIN MISSIONS AND TO A SPECIAL CAREER FIELD OF AIR-TO-AIR

The explicit statement put forward in our question to the pilots (see Figure 2.3-1), that "career" limitations would be part of a "dedicated" pilot program caused considerable pilot response. The majority of pilots wrote strong responses clearly stating that pilots should be dedicated to a specific career field, but that this should not limit progression.

The Air University research report by Anderson (1972), mentioned earlier, also has high relevance for the issue of improving combat effectiveness through specialization within pilot training, as well as the creation of a limited fighter pilot career field. The following quotes are taken from Anderson (1972).

> "[Another]. . . great need of the Air Force is to create an environment which fosters the retention of tactical fighter pilots in the cockpit for the entirety of their career in the Air Force. The dual need filled by pilot training for pilots and officers will continue to exist; however, two separate career options must be established to meet this need. . .
>
> "A 'pilot only' career pattern must be established to. . .
>
> > 'Increase utilization of pilot skills in active flying billets during the (span of the specific period). . . (and) will offer advantages of increased pilot proficiency with resultant improvement in combat readiness and flight safety.'
>
> "Current and past dissatisfaction with the pilot career field have been largely due to the lack of a well defined career pattern for every individual entering pilot training. This is especially true when junior officers are able to view the inconsistencies of a personnel plan which must rely on "surge" and "drawdown" rather than retention to fill pilot vacancies created by the attrition of retirement and combat losses. Pilots returned to the cockpit two and three times is not only demoralizing, but it is extremely expensive. Replacing the current system in which the pilot retention rate averages 46% with one in which, after ten years the average retention rate is 73% would, according to the Logistics Management Institute, result in a differential cost of $217 million per year. The 73% retention rate at 10 years closely approximates the value which could be expected from a pilot only fixed career pattern." (Anderson, 1972, pp. 37-39)

2.4 PILOT READINESS AND AIR COMBAT MANEUVERING RANGE BENEFITS AND LIMITATIONS

Not surprisingly, an overwhelmingly 89% of all the pilots agreed or strongly agreed with the wording of our question concerning adequate training for combat readiness.[4] The histogram in Figure 2.4-1 shows a breakdown of pilot opinion.

No written responses were requested for this particular question. However, we did ask the pilots what they thought the principal benefits and limitations of air combat maneuvering training were. Their selected responses are also shown in Figure 2.4-1. The comments made it quite clear that the pilots think there are tremendous benefits associated with air combat maneuvering range training. On the other hand, they do emphasize the absence of certain important elements of actual combat.[5] The question of whether or not the air combat maneuvering ranges offer authentic test beds for "predicting" to combat is considered in Section 2.9.

2.5 PILOT OPINION CONCERNING FORCE STRUCTURE

The military, in general, is faced with steeply escalated manpower costs, inflation, and the continuing presence of real and threatened budget cuts.

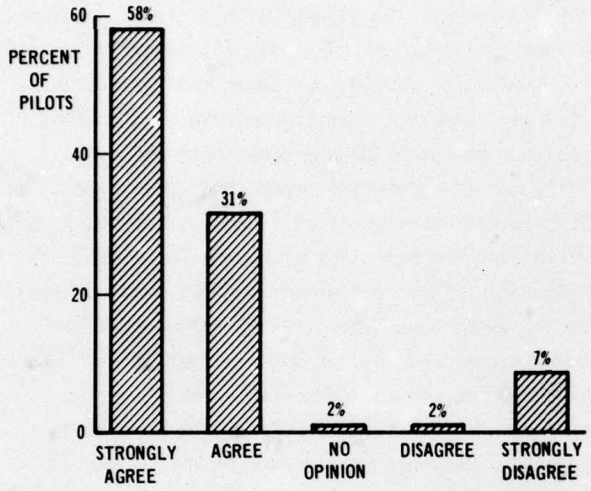
In light of this, we sought out pilot opinion to the following question, "Our current military budget is causing severe cuts in proficiency training. These budget cuts can be made a number of ways. In your opinion, would it be better to, (1) have fewer pilots trained to top effectiveness,

---

[4] Readiness issues involving an entire combat system are beyond the scope of this study but a subject, of course, of considerable interest. Illustrative studies of naval air combat readiness (Boissenin, 1966; Dunn, 1964; Feare, 1963; and Whelchel, 1965), Army air mobility performance (Alluisi, 1964), and Air Force readiness (Operational Readiness criteria for tactical forces, 1975) are identified in the Reference section of this document.

[5] These issues are treated in more depth in Section 6.2.3 which deals with the utilization of air combat maneuvering ranges as potential "testbeds" in an improved pilot selection program.

STATEMENT:
OUR MODERN HIGH PERFORMANCE AIR-TO-AIR COMBAT AIRCRAFT SHOULD BE PILOTED BY PILOTS WHO RECEIVE ADEQUATE TRAINING SORTIES TO MAKE THEM COMBAT READY AT ALL TIMES.



QUESTION:
WHAT DO YOU THINK ARE THE PRINCIPAL BENEFITS AND LIMITATIONS OF ACMR TRAINING?

SELECTED PILOT RESPONSES ON ACMR/I AS A TRAINING DEVICE:

WITHOUT THE THREAT OF IMMINENT DEATH, YOU'LL NEVER EVER BE SURE, BUT ACMI COMES AS CLOSE (ALONG WITH RED FLAG EXERCISES) IN PUTTING PRESSURE ON EACH PILOT TO SCORE WELL, AND CLEARLY DOCUMENTS HIS HEAD/HAND WORK.

THE BENEFITS ARE GREATLY MAGNIFIED IN TODAY'S COMBAT, AS MORE AND MORE IT IS A DUEL BETWEEN SOPHISTICATED EQUIPMENT, AND THE BETTER TRAINED A PILOT IS IN MAXIMIZING HIS ELECTRONIC EQUIFMENT, THE BETTER CHANCE HE HAS TO WIN. BUT A MENTAL ALERTNESS AND COMPETITIVENESS MUST BE THERE TO OPERATE THE GEAR PROVIDED AND TO MAKE A KILL AND SURVIVE.

FROM WHAT I KNOW OF IT, I THINK IT IS THE BEST THING SINCE THE JET ENGINE – IF PROPERLY UNDERSTOOD AND USED BY THE COMMANDERS INVOLVED.

NO B.S. AS TO WHO SHOT WHO, WHO WAS ACTUALLY IN FIRING ENVELOPE, ETC. WHAT TACTICS EMPLOYED.

MISTAKES ARE OBVIOUS AND CAN BE STUDIED IN DEPTH WHICH PRECLUDES PILOT MISTAKES OVER AND OVER WITHOUT KNOWING WHY = $ SAVINGS LONG TERM.

IT IS A TRAINING TOOL. IT DOES NOT OBVIATE THE NEED OF A GIFTED INSTRUCTOR TO ANALYZE THE FIGHT IN THE AIR WITH ACMR AS AN AID – DON'T FORGET THIS! ITS LIMITATIONS TECHNICALLY ARE FEW.

IT TEACHES A PILOT HOW TO MANEUVER HIS AIRCRAFT INTO POSITION TO KILL. IT ALSO GIVES A PILOT THE REAL FEEL OF HIS AIRCRAFT AND HOW IT IS TO HANDLE IT.

BENEFITS: SEE YOUR ERRORS PRESENTED IN REAL TIME. PERMITS ANALYSIS OF YOUR MENTAL CONCEPT OF THE ENGAGEMENT AS IT WAS OCCURRING.

LIMITATIONS: TRYING TO BEAT THE SYSTEMS "GAMESMANSHIP" MAY CREATE BAD HABITS THAT WOULD GET YOU KILLED IN THE REAL WORLD.

BENEFITS: LEARNING HOW TO HANDLE THE A/C TO ITS MAXIMUM POTENTIAL AND LEARNING HOW TO MANEUVER INTO AN ATTACK POSITION.

LIMITATIONS: NO ELEMENT OF FEAR IF YOU LOSE AND ONLY A SELF SATISFACTION IF YOU WIN. (WHILE THE DESIRE TO WIN IS USUALLY SUFFICIENT, DEATH MAKES LOSING COMPLETELY UNACCEPTABLE).

GIVES A PARTICIPANT A CHANCE TO FLY AGAINST UNLIKE AIRCARFT AND A MEANS TO BETTER ANALYZE WHAT HE DID RIGHT AND WRONG DURING AN ENGAGEMENT. LIMITATIONS ARE THOSE NECESSARY TO ASSURE FLIGHT SAFETY AND FAIRLY RIGID SCENARIOS.

I BELIEVE ANY ACMR EXPERIENCE IS BENEFICIAL BUT THAT IT CANNOT SIMULATE EVERY SITUATION THAT WILL BE MET IN AIR-TO-AIR COMBAT. BELIEVE THAT ACMR IS A GOOD INDICATOR OF WHAT COULD BE EXPECTED OF A PILOT WHEN THE CHIPS ARE DOWN.

IT PROVIDED THE MOST REALISTIC TRAINING I HAVE EVER EXPERIENCED OUTSIDE OF SEA. I WOULD THINK THIS PRIMARY LIMITATION IS FINANCIAL. THE EQUIPMENT IS EXPENSIVE AND WOULD NOT BE AVAILABLE TO ALL UNITS ON A REGULAR BASIS. I THINK THE AGGRESSOR PROGRAM IS AN EXCELLENT SECOND CHOICE.

BENEFITS: ARE THAT EVERY SHOT IS ANALYZED AND PILOTS GET VALUABLE EXPERIENCE IN ESTIMATING WHICH ARE GOOD SHOOTING POSITIONS AND WHICH ARE NOT. RANGE ESTIMATION AND VERIFICATION ARE ALL IMPORTANT.

LIMITATIONS: YOU CANNOT ACTUALLY SHOOT DOWN AIRPLANES; YOUR ALTITUDE MIN IS FIXED – THERE ARE CERTAIN ARTIFACTS BUILT INTO A TRAINING ENVIRONMENT BY NECESSITY.

FIGURE 2.4-1 PILOT OPINION CONCERNING TRAINING FOR COMBAT READINESS AND THE VALUE OF AIR COMBAT MANEUVERING RANGE TRAINING

(2) have a full complement of pilots trained as well as you can within the assigned budget, (3) have a mix of pilots some at full and some at partial efficiency?"

Pilot responses to this question are shown in Figure 2.5-1. One-third of the pilots thought that

9-1113

QUESTION:

OUR CURRENT MILITARY BUDGET IS CAUSING SEVERE CUTS IN PROFICIENCY TRAINING. THESE BUDGET CUTS CAN BE MADE IN A NUMBER OF WAYS. IN YOUR OPINION WOULD IT BE BETTER TO: (CHECK ONE)

(1) HAVE FEWER PILOTS TRAINED TO TOP EFFECTIVENESS.	33%
(2) HAVE A FULL COMPLEMENT OF PILOTS TRAINED AS WELL AS YOU CAN WITHIN THE ASSIGNED BUDGET.	26%
(3) HAVE A MIX OF PILOTS SOME AT FULL AND SOME AT PARTIAL EFFICIENCY.	41%

FIGURE 2.5-1 PILOT OPINION CONCERNING PILOT FORCE TRAINING IN THE FACE OF BUDGET REALITIES

it would be best to have fewer pilots trained to top effectiveness. Over a third of the pilots felt that a mix of pilots, some at full and some at partial efficiency, would be the preferred approach. Twenty-six percent of the pilots felt that it would be best to dilute pilot proficiency across the Air Force and have a full complement of pilots trained as well as possible within the assigned budget.

Pilot training philosophy mix is but one aspect of, or solution to, the more global problem facing the military at this time. Overall budgetary considerations have forced a substantial reduction in the size of the pilot force that can be maintained by the military. The services, therefore, are confronted with the problem of maintaining readiness and combat effectiveness during a period when fewer pilots are available.

While part of the larger overall issue of manpower planning[6], one of the areas where the application of selection techniques can materially impact force readiness is in the area of selecting for combat effective pilot qualities as well as selection for the aviator's probability of staying within the force structure, i.e., retention in the military.

Understandably, each of the services has studied the factors associated with the retention of aviators as well as other career fields. For example, research on a group of U.S. Army aviation warrant officers, of which only 25% continued beyond their obligated period, has shown that responses to a "career intention" questionnaire are an accurate predictor of retention and nonretention, particularly for the departing group (Boyd and Boyles, 1968; Boyd and Boyles, 1969). Some of the factors influencing the retention of Marine Corps officers (Klingerman, 1970) and Naval aviators (Howard, 1965; Nelson, 1958) have been studied. From our literature search, however, it appears that the Air Force has conducted the most research in this area. Calclasure (1971), under Air Force sponsorship, has produced a comprehensive review of the literature dealing with career motivational predictions and selection procedures. The Human Resources Research Organization (HumRRO), under contract to the Air Force Human Resources Laboratory (AFHRL), has produced a comprehensive analysis of the classification, assignment and separation systems of the Air Force, Army, Marine Corps, and Navy (Harding and Richards, 1971). Alvord and Ewing (1964) have reported upon the Air Force's "Project M" which traced the retention of 72,000 officers entering the Air Force from 1955 through 1962. Retention rates are reported by year of entry, procurement source, flying status, education, age, Air Force Officer Qualifying Test (AFOQT) score, and by career-field assignment. Additional Air Force sponsored research has shown a relationship between retention and various demographic and attitudinal

[6]Both the Air Force (e.g., Kildebeck, et al, 1969; Kipnes, 1970) and the Navy (e.g., Taylor and Arzigian, 1970) have developed mathematical manpower "models" which permit planners to ask, "What if" questions involving the prediction of pilot training requirements. One model (Kildebeck, et al, 1969), for example, can predict the number of pilots by aircraft type that would be required for the successful military conduct of any given (hypothesized) scenario.

factors (Ewing, 1967; Shenk, 1969) as well as type of college attended and type of degree awarded (Ewing, 1965; Tupes and Madden, 1968).

While we will not review these studies in detail within this context, it should be pointed out that they do form an excellent empirical data base on which to build an officer "selection-for-retention" program. While the degree of relationship between the predictor variables and the retention of the officer in the military is, in all probability, not strong enough to be used across the entire entering officer corps in general, they are of sufficient goodness that a program could be developed for high retention for selected career fields, such as air-to-air fighter pilots.

While the main thrust of our effort in this study will be the development of a technique to select for air-to-air combat effectiveness, there appears to be no technical reason why selection-for-career-retention could not be included within a larger selection-for-combat-effectiveness selection program. If that were to be the case, however, a more detailed reexamination of the retention data which we have alluded to here would have to be undertaken and integrated into the overall combat effectiveness selection program.

Two recent Air University research reports have treated the issue of retention in the military and cockpit (Karalus, 1970; Anderson, 1972). Karalus (1970) begins his argument by quoting from the then new "officer personnel objective structure (Topline)."

> "The Air Force is short of pilots...the magnitude of this shortage is 5500...the trend indicates that pilot production will not equal pilot losses through 1974...there is little doubt that the Air Force will begin the next major contingency with the pilot force of far less size than which it began in Viet Nam..." (p. 2).

Karalus then focuses on one very obvious area where retention rates for Air Force aviators might be improved, and that is by looking at the predictor variable of input source. The data shown in Figure 2.5-2 has been adapted from Karalus' report, and by inspection it can be seen that by using the predictor of input source alone, that a substantial improvement in retention could be made if Air Force policy were modified so that only high retention[7] groups were considered for pilot training. We show the above data as illustrative only; we are making no strong recommendation that such a policy change be implemented by itself. Rather, the data show that there are dramatic differences in attrition rates as a function of input source. Similar kinds of predictors of retention in a particular career specialty (in this case, pilots) could, we think, be developed from the substantial data base which we find in the literature. These could be included in an overall selection program developed to produce combat effective air-to-air pilots.

9-1112

ACTIVE AIR FORCE SOURCE	PERCENT ENTERING	PERCENT ATTRITION (ALL CAUSES)
OTS (OFFICER TRAINING SCHOOL) COLLEGE GRADUATES	46	34
ROTC (RESERVE OFFICER TRAINING CORPS)	27	22
AFA (AIR FORCE ACADEMY)	9	12
RATED (AIR FORCE OFFICERS) (NAVIGATORS)	1	7
NONRATED AIR FORCE OFFICERS	6	34
OTHER:		
MARINE	4	12
ANG (AIR NATIONAL GUARD)	4	22
FOREIGN	3	23

FIGURE 2.5-2 ATTRITION RATES OF UPT STUDENTS AS A FUNCTION OF ENTRY SOURCE (FY 1969)

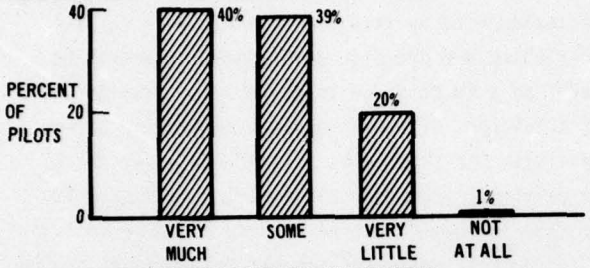
2.6 PILOT OPINION ON THE EFFECT OF OUT-OF-COCKPIT ASSIGNMENTS ON PILOT COMBAT FLYING SKILLS

This section assesses pilot opinion concerning the effect of various out-of-cockpit assignments upon air-to-air combat effectiveness. To that end we asked the various questions shown in Figure 2.6-1.

[7]Technically, the author is talking about attrition in pilot training, yet his point is a good one.

STATEMENT:
A SUBSTANTIAL NUMBER OF PILOTS ARE OFFERED CAREER BROADENING OPPORTUNITIES EARLY IN THEIR FLYING CAREER. THESE JOBS ARE GENERALLY NON-FLYING MANAGEMENT POSITIONS. SUCH ASSIGNMENTS, WHILE IMPORTANT TO CAREER DEVELOPMENT, BREAK THE CONTINUITY OF DEVELOPMENT OF THE PILOTS' COMBAT FLYING SKILLS.

QUESTION:
HOW MUCH DO YOU THINK THIS DISCONTINUITY WILL AFFECT THE LATER AIR-TO-AIR COMBAT EFFECTIVENESS OF THESE PILOTS?



SELECTED PILOT COMMENTS REGARDING THIS QUESTION:

VERY MUCH – I HAVE PERSONAL EXPERIENCE IN THIS AREA HAVING BEEN FORCED INTO A NON-FLYING POSITION FOR 3½ YEARS. IT HAS BEEN EXTREMELY DIFFICULT TO REGAIN MY FORMER LEVEL OF COMPETENCE; I RETURNED TO FLYING A YEAR AGO AND AM STILL NOT SATISFIED WITH MY LEVEL OF PROFICIENCY/TACTICAL ABILITY.
AIR NATIONAL GUARD

VERY LITTLE – I'M WILLING TO BET THAT 90% OF THE WWII ACES NOW LIVING COULD HACK THE SAME PROBLEM WITH A MONTH OR TWO REFRESHER IN THE SAME AIRCRAFT THEY FLEW AND WITH THE SAME WEAPONS SYSTEM, HEALTH PERMITTING. I THINK IT STAYS WITH YOU AS AN ATTRIBUTE. BUT I DO SENSE WE'RE REALLY CONCERNED WITH TWO KINDS OF AIR-TO-AIR COMBAT TODAY: 1) GUNS AND SHORT RANGE ROCKETS AND 2) LONG RANGE ROCKETS (5 MILES TO 15 MILES) WHERE IT'S ME AND MY RADARSCOPE AGAINST A BLIP.
AMERICAN FIGHTER ACE

QUESTION:
ASSUMING THAT YOU WOULD EVENTUALLY BE REASSIGNED TO AN AIR-TO-AIR COMBAT ROLE, HOW LONG WOULD YOU BE WILLING TO BE OUT OF THE COCKPIT FOR ANOTHER TYPE OF ASSIGNMENT?

SELECTED PILOT COMMENTS REGARDING THIS QUESTION:

VERY MUCH – I DON'T THINK ANY PILOT SHOULD EVER BE "OUT OF THE COCKPIT." IN OTHER WORDS, TO BE CONSISTENT ABOUT THE FIRST PART OF THE SLOGAN: "OUR BUSINESS IS TO FLY AND TO FIGHT," WE HAVE TO OBEY THE SECOND PART: "DON'T YOU EVER FORGET IT." I AM DOGMATICALLY OPPOSED TO THE PRESENT "BUDGET"-MOTIVATED DEVELOPMENT WHICH HAS ELIMINATED CRT. SOME KIND OF FLYING IS MANDATORY FOR RATED OFFICERS ON FIGHT FLIGHT-RELATED STAFF ASSIGNMENTS.
RIVER RAT

VERY MUCH – PILOTS ARE MOST EAGER AND LEARN MOST IN THE EARLY YEARS OUT OF FLYING SCHOOL. THESE SHOULD BE THE YEARS OF INTENSIVE FLYING TRAINING WITH MANAGEMENT TRAINING SECONDARY. AFTER THE PILOT HAS MASTERED THE ART THEN MANAGEMENT DUTIES CAN BE ASSUMED ON AN INCREASING BASIS.
AMERICAN FIGHTER ACE

SOME – AFTER ABOUT AGE 35 YEARS, I BELIEVE PHYSICALLY AND MENTALLY, A FIGHTER PILOT WILL BE "BURNT OUT." THE BEST YEARS FOR TOP PROFICIENCY ARE THE 20s.
AMERICAN FIGHTER ACE

FIGURE 2.6-1 PILOT OPINION ON THE EFFECT OF OUT-OF-COCKPIT ASSIGNMENTS ON PILOT COMBAT FLYING SKILLS

In response to the question, "How much do you think discontinuities will affect the later air-to-air combat effectiveness of these pilots?", forty percent thought that such assignments would "very much" affect later combat effectiveness. Thirty-nine percent of the pilots thought that there would be some effect. Twenty-one percent of the pilots felt that there would be very little or no effect at all. Representative written responses reflecting both ends of the spectrum are also presented in Figure 2.6-1.

Responses are also given typifying the replies to the following question, "Assuming that you would eventually be assigned to an air-to-air combat role, how long would you be willing to be out of the cockpit for another type of assignment?" The most frequent duration that pilots reported they would be "willing to be out of the cockpit" was three to six months. Many pilots were rather adamant about spending any time out of the cockpit.

Out-of-cockpit pilot assignments are used for a number of purposes within military aviation, but

generally all under the aegis of the career officer broadening his career base in preparation for more senior managerial assignments. The positive aspects of this policy will not be described here. However, three frequently referred to negative aspects of taking the pilot out of the cockpit will be discussed. They are (1) reduction in effectiveness as a result of cumulative lack of experience, (2) the increase in accidents as cockpit time is decreased, and (3) the issue of currency or readiness.

The role of total cockpit experience time as it relates to operational effectiveness will be developed in detail in Section 3.1. We will find that experience was positively correlated with combat kills, both in Korea and Southeast Asia.

Anderson (1972) and Cooper, et al, (1976) have reviewed aviation accidents with respect to cockpit experience from two slightly different perspectives.[8]

To quote from Anderson (1972):

> "In addition to improved combat effectiveness, increased flying experience and pilot age are significant factors which are directly related to decreasing aircraft accidents. An analysis of pilot error accidents in a group of 16 F-86 pilots, after completing upgrading training in an operational training unit, revealed that, those pilots who were in the middle-aged group, with a median age of 27 years, who had jet aircraft background were more proficient and had a lower accident potential than either recent graduates of pilot training (median age of 21), or older pilots, median age of 39, who had no jet aircraft background.
>
> "The USAF Sabre Wings Study of Pilot Proficiency (USAF Tactical Air Weapons Center, 1973a, 1973b, 1974a, 1974b) points out the following:
>
> > 'Analysis of F-4 Combat Crew Training Schools performance scores of pilots with background in like aircraft to those pilots with unlike backgrounds as a function of age indicated that age and aircraft background were significant variables in determining pilot performance. Pilots with like backgrounds did significantly better than pilots with unlike backgrounds. Additionally, age was a significant factor for pilots with unlike aircraft backgrounds. Pilots less than 37 years performed significantly better than those 37 and over.
>
> "These two studies, taken together, suggest that a policy which retains pilots in aircraft of similar performance and mission for extended periods of time, would be advantageous from the point of view of increasing combat effectiveness and reducing pilot error accident potential. . . With regard to performance, data gathered from gunnery and dive-bombing meets suggest that fighter pilot capabilities are directly correlated with experience measured in hours. Analysis of one command-wide gunnery meet pointed out important differences in dive-bombing accuracy on both sides of 1500 hours of flying experience. . . The results of this analysis showed that the probable circular error (CEP) for pilots with greater than 1500 hours was 54 feet smaller than that of pilots with less than 1500 hours." (Anderson, 1972, pp. 28-30)

Taken together, these isolated instances form a pattern which argues strongly for the importance of age, and flying experience and perhaps even more strongly for continuity of aircraft background in attaining maximum fighter pilot combat capability.

To quote from Cooper, et al, 1976:

> "In 1974 alone, USAF flight accidents cost 98 lives and more than $250 million in equipment. . . [Accident trend analysis has shown that] FAR aircraft have a higher accident rate than do TTB aircraft. During the early 1960's the FAR accident rate was approximately five times that of the TTB rate. More recently, the FAR accident rate has been two to three times greater. . . [see Figure 2.6-2]
>
> "Variation in missions between the FAR and TTB roles probably accounts for the variation in accident rates. The FAR mission routinely places the pilot in an error-sensitive environment where inattention, distraction, or minor misjudgments could readily cause an accident. . . Repeated flight into error-sensitive environments should lead to higher occurrences of pilot error accidents. Historically, that has been the case. The percentage of accidents attributed to pilot error is higher for FAR aircraft than for TTB aircraft [see Figure 2.6.3]." (Cooper, et al, 1976, pp. 19-21)

[8]Aviation accident research constitutes a rather large literature. A substantial number of references are provided the interested reader in our bibliography (see Section 9).

9-1119

YEAR	FIGHTER[3]	ATTACK[1]	TRANSPORT[2]	BOMBER
1960	22.2		1.7	3.8
1961	24.2		1.7	3.2
1962	24.0		3.3	6.9
1963	18.1		1.5	2.0
1964	17.6	9.7	1.8	4.5
1970	9.7	10.3	1.5	4.8
1971	8.5	8.6	1.2	3.7
1972	9.0	11.6	1.5	5.5
1973	9.5	10.2	1.2	4.2
1974	7.8	7.5	1.5	5.2

ACCIDENT RATES DO NOT INCLUDE LOSSES DUE TO COMBAT IN SOUTHEAST ASIA.

[1]FROM 1960–1963 NO DISTINCTION WAS MADE BETWEEN FIGHTER AND ATTACK.

[2]TANKER AIRCRAFT ACCIDENTS ARE INCLUDED IN TRANSPORT RATES.

[3]RECCE AIRCRAFT ACCIDENTS ARE INCLUDED IN FIGHTER ACCIDENT RATES.

FIGURE 2.6-2 AIRCRAFT ACCIDENT RATE PER 100,000 FLYING HOURS (Compiled from USAF Accident Bulletins 1960–1974, 1970–1974).

9-1118

	FIGHTER	ATTACK	TRANSPORT	BOMBER
TOTALS	296	37	104	49
PILOT ERRORS	81	11	21	8
	27%	30%	20%	16%

FIGURE 2.6-3 ACCIDENTS ATTRIBUTED TO PILOT ERROR 1970–1972 DUE TO INCORRECT OPERATION OF AIRCRAFT SYSTEMS; POOR TECHNIQUE IN FLIGHT, POOR TECHNIQUE IN PATTERN (Compiled from USAF Accident Bulletins, 1970–1972)

The out-of-cockpit effect on pilot readiness has recently been reviewed by Prophet (1976a). This study, conducted in support of the USAF Sabre Wings II Study, reviews the literature concerning the long term retention of flying skills. Prophet's review is supplemented by an annotated bibliography (Prophet, 1976b). The review, conducted for the Air Force Assistant Chief of Staff for studies and analysis, is comprehensive and treats many of the historical and methodological issues which abound in skill retention kinds of research.

Certain highly relevant studies reviewed in Prophet's report (see Figure 2.6-4) indicate that:

> "In sum, . . .USAF data suggest that basic flying skills are surprisingly well retained over quite extended and most difficult non-flying episodes, i.e., time spent as a POW. Retraining to acceptable proficiency levels, Smith and Matheny (1976) conclude, could be accomplished in an average of 50 hours or less. They conclude also that abolition of continuation training could result in significant cost savings for the Air Force and should be investigated. Several points should be kept in mind with reference to these data, however. First, this was a highly special and individualized program. There is no assurance that the pilots were retrained to a common level of proficiency. In fact, it is likely that they were not, so the retraining time measures may be inappropriate. Second, the retraining program was not oriented to tactical skills in operational combat aircraft. Also, it can be argued that this is a unique group of personnel in terms of motivational factors. All in all, however, it presents a convincing demonstration, the most dramatic to date, of the high retention of flight skills over extremely long periods of time and of the relative ease with which required proficiency can be regained." (Prophet, 1976a, p. 49).

While a considerable amount can be concluded in the general area of skill retention and the retention of flight specific psychomotor and procedural tasks, there remains one methodological problem that will continue to require a solution before definitive answers can be given with regard to effective out-of-cockpit time upon combat effectiveness. Notably, some specific agreed upon level of combat related performance, perhaps within an air combat maneuvering range, must be established before one can assess the subordinate question of retention of that specific performance level.

2.7 PILOT ATTITUDES CONCERNING THE SUBSTITUTION OF SIMULATOR TIME FOR ACTUAL FLIGHT TIME

Another expedient which may have to become a reality given the budgetary considerations which face the military today is the substitution of simulator "training" time for actual flight hours. In a number of private discussions with pilots, we came away with the feeling that they were very

9-1131

STUDY	PRINCIPAL TECHNICAL CONCLUSIONS	RECOMMENDED ACTION
WRIGHT, 1969	(1) FLIGHT SKILLS ARE RETAINED WELL FOR PERIODS UP TO TWO YEARS, AND RETRAINING IS RAPID; (2) PROCEDURAL SKILLS LACKING INTERNAL ORGANIZATION ARE RAPIDLY FORGOTTEN.	LEAST-COST OPTION FOR THE ARMY WOULD BE COMPLETE CESSATION OF PROFICIENCY FLYING DURING NON-FLYING ASSIGNMENTS FOLLOWED BY RETRAINING SPECIFIC TO THE NEXT ASSIGNMENT. HE PUSHES FOR USE OF TRAINING DEVICES IN THE MAINTENANCE AND RETRAINING OF FLIGHT SKILLS.
SMITH AND MATHENY, 1976	– SIMILAR TO ABOVE–	USAF PILOTS CAN BE RETRAINED IN CONTACT AND INSTRUMENT FLIGHT SKILLS IN 50 HOURS OR LESS AFTER EXTENDED PERIODS OF NON-FLYING. THEY RECOMMEND THAT EXISTING CONTINUATION TRAINING FOR USAF RATED SUPPLEMENT PILOTS BE REEXAMINED TO DETERMINE IF RECURRENT TRAINING MIGHT BE FEASIBLE AND MORE COST EFFECTIVE THAN CONTINUATION TRAINING AND TO DETERMINE THE MOST EFFECTIVE USE OF GROUND TRAINING DEVICES IN MAINTAINING/REGAINING PILOT PROFICIENCY.
SMODE, HALL, AND MEYER, 1966	– SIMILAR TO ABOVE – "RESEARCH ON RETENTION, AS PRESENTLY CONCEIVED, HAS REACHED AN IMPASSE. THE SAME CONCLUSIONS CONTINUE TO BE GENERATED WITH VERY LITTLE ADDITIONAL SUBSTANCE ADDED."	THEY CALL FOR PROGRAMMATIC RESEARCH ON FORGETTING IN TERMS OF THE CHARACTERISTICS OF COMPLEX TASKS AND OVER LONGER PERIODS OF TIME, AND THEY ALSO NOTE THE NEED FOR A BETTER UNDERSTANDING OF AND MEANS FOR MEASURING LEVELS OF LEARNING IN FLIGHT TASKS.

FIGURE 2.6-4 RECENT SKILL RETENTION ANALYSES

negative about any substitution of simulator time for flight time, indicating that flight time is already at a minimum. However, we wanted to go beyond the opinion of a few pilots and assess the issue more systematically. We, therefore, asked the pilots in our sample the question shown in Figure 2.7-1. The essence of the question suggests that modern simulators can reach very high levels of fidelity and that it is implicit that pilots will have to use them. The question explicitly lets them decide between various functions according to which they would most willingly substitute simulator for flight time.

The results of our analysis of the pilot responses is shown in Figure 2.7-1. Overall, the pilots are much more willing to substitute simulator time for general procedures, instrument flying and communications coordination than any of the other flight components shown in Figure 2.7-1.

It is significant to note that a number of spontaneous responses to this question indicated that simulator time was meant to be an adjunct to flight training time. Many pilots indicated that

QUESTION: 9-1110

SIMULATORS HAVE ADVANCED TO THE POINT WHERE ALMOST ALL VISUAL AND AIRCRAFT CONTROL FUNCTIONS CAN BE REALISTICALLY PRESENTED TO THE PILOT. GIVEN THAT SUCH MODERN SIMULATORS ARE BEING USED, *TO WHAT EXTENT DO YOU FEEL SIMULATOR TIME CAN BE SUBSTITUTED* FOR FLYING TIME FOR THE FOLLOWING FUNCTIONS? (BASED ON 100% FOR EACH FUNCTION)

FUNCTION	% OF TIME SIMULATORS	% OF TIME FLIGHT TRAINING
GENERAL PROCEDURES	42	58
TAKE OFF	22	78
LANDING	17	83
INSTRUMENT FLYING	41	59
AIR-TO-AIR COMBAT ONE VERSUS ONE	18	82
AIR-TO-AIR COMBAT TWO VERSUS ONE	16	84
AIR-TO-AIR COMBAT TWO VERSUS TWO	14	86
AIR-TO-AIR	14	86
AERIAL GUNNERY	17	83
COMMUNICATIONS COORDINATION	44	56
AIR-TO-GROUND ATTACK	17	83

FIGURE 2.7-1 PILOT ATTITUDES CONCERNING THE SUBSTITUTION OF SIMULATOR TIME FOR ACTUAL FLIGHT TIME FOR VARIOUS KINDS OF PILOT TASKS (FUNCTIONS)

the simulators should be used in addition to flying, not instead of flying. Despite this attitude, however, a relatively significant degree of training time appears to be acceptable in simulators for general procedures, instrument flying, and communications coordination.

2.8 PILOT OPINION CONCERNING THE PERFORMANCE OF PILOTS IN AIR COMBAT MANEUVERING RANGES AND IN COMBAT

Because of our particular research interest, this question was extremely important. The thrust of our recommended pilot selection research program is to develop a battery of discriminating tests applied to candidate pilots very early on in the program and, ultimately, to correlate these tests with the performance of the same pilots in a structured air combat maneuvering range series of engagements.

We were aware of the frequently expressed reservations that pilots place upon ACMR/Is. These reservations are understandable since although there are similarities between ACMR/Is and actual combat, there are also significant differences. Nevertheless, the ranges may be close enough to combat to produce good correlations. To determine pilot opinion on this, pilots were asked whether or not they thought that performance in the air combat maneuvering range would predict to actual combat.

Following the statement concerning air combat maneuvering ranges shown in Figure 2.8-1, we asked the pilots the following two questions, "Do you feel that pilots who perform well on the ACMR will perform well in actual air-to-air combat?" and, "Do you think that pilots who perform poorly in ACMR will do poorly in actual air-to-air combat?" The results to both of these questions are shown in Figure 2.8-1. Also shown in Figure 2.8-1 are some representative pilot comments concerning the limitation of ACMRs in actually duplicating combat.

About two thirds of the pilots agreed (or strongly agreed) that pilots who performed well in an ACMR program would perform well in combat; only 12% of the pilots disagreed (or strongly disagreed) with this premise.

The pilots also thought that poor ACMR performers would do poorly in combat; 54% agreed or strongly agreed.

Overall, it appears that the pilots were more certain about the good ACMR performers doing well in combat than they were about the poor ACMR performers doing poorly in combat.

Based upon these pilot responses, we feel much more confident in advancing air combat maneuvering ranges as a peacetime combat surrogate within which we can assess the performance of aviators and, in turn, relate this performance (good or bad) to the scores derived from a selection test battery. (See Sections 6.0 and 7.0 for Implementation Approaches)

2.9 PILOT OPINION CONCERNING SELECTION STANDARDS FOR PILOTS

Another question of particular concern to us was the pilot opinion concerning existing selection standards for high performance air-to-air combat pilots. If the pilots were to think that the standards were satisfactory as they are currently applied, then we, as proponents of improved selection techniques, would be proceeding on very thin ice.

In response to our question (see Figure 2.9-1), we found that two thirds of the pilots either strongly agreed or agreed that standards should be more selective than those currently used for assignment to air-to-air combat aircraft. Only 11% disagreed or strongly disagreed with the statement.

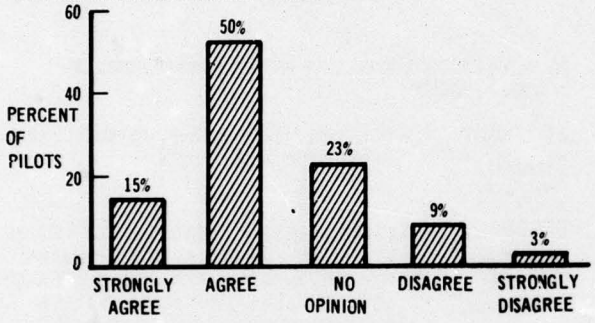
We did not solicit written responses from the pilots for this particular question. However, a number of general comments were received. If we were to characterize these and the verbal responses collected during our site visits, they would

indicate that: "Yes, of course, selection standards need to be improved. Anybody can see that. How to do it, I am not quite sure - you're the psychologist - you tell me."

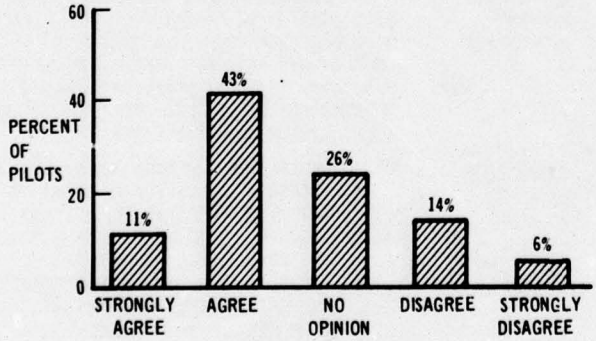
This is what the remainder of this report is concerned with. Can we devise a way to construct and demonstrate criteria for selecting air-to-air fighter pilots? The prediction to combat success, of course, has been the subject of a substantial number of scientific studies, is the preoccupation of many authors in the popular domain, and has (at least by implication) been treated by the aviation selection research community of the United States and foreign governments. We will now turn our attention to a review of the information published in this area.

9 - 1109

QUESTION:
DO YOU FEEL THE PILOTS WHO PERFORM WELL ON THE ACMR WILL PERFORM WELL IN ACTUAL AIR-TO-AIR COMBAT?



QUESTION:
DO YOU THINK THE PILOTS WHO PERFORM POORLY IN ACMR WILL DO POORLY IN ACTUAL AIR-TO-AIR COMBAT?



STATEMENT:
THE AIR COMBAT MANEUVERING RANGE (ACMR) OPERATED BY THE NAVY AT YUMA, ARIZONA AND ITS AIR FORCE COUNTERPART, THE AIR COMBAT MANEUVERING INSTRUMENTATION (ACMI) NEAR LAS VEGAS PROVIDE THE CAPABILITY TO KEEP TRACK OF A MULTI-AIRCRAFT AIR COMBAT ENGAGEMENT. THE SYSTEM TRACKS EACH AIRCRAFT'S POSITION WITHIN A 30 NAUTICAL MILE DIAMETER AREA EXTENDING FROM 5000 FT TO 50,000 FT. EACH AIRCRAFT, THROUGH A SPECIAL INSTRUMENTATION POD MOUNTED ON THE AIRCRAFT, TRANSMITS ESSENTIAL AIRCRAFT DATA (ANGLE OF ATTACK, "G," MACH, TRUE AND INDICATED AIRSPEED, ETC.) TO THE GROUND STATION. THESE DATA CAN BE MONITORED BY GROUND OBSERVERS ON LARGE SCALE DISPLAYS, WHILE THE ENGAGEMENT IS UNDERWAY AND/OR RECORDED FOR LATER PLAYBACK TO THE AIRCREWS DURING THE DEBRIEFING.

SELECTED PILOT COMMENTS REGARDING THE RELATION BETWEEN ACMR/I AND COMBAT:

YOU CANNOT DETERMINE BY ANY TEST WHAT A MAN WILL DO WHEN IT BECOMES NECESSARY TO KILL OR BE KILLED. YOU CAN UNDOUBTEDLY DETERMINE MANY OF HIS ABILITIES BUT NOT THIS ABILITY TO ACT CALMLY WHEN HIS LIFE IS AT STAKE. THOSE WHO CAN ACT CALMLY IN TIGHT CIRCUMSTANCES HAVE AN UNBELIEVABLE ADVANTAGE.

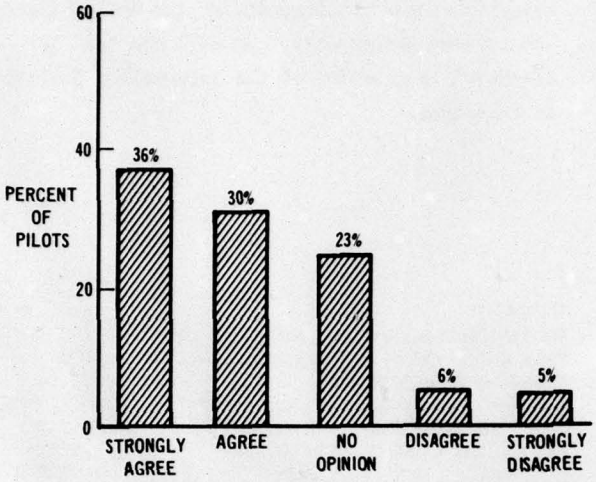
THE LIMITATIONS ARE THAT REAL BULLETS ARE NOT BEING FIRED. SOME PILOTS ARE GOOD IN ACM, BUT THEN CANNOT FACE THE REAL THING.

ACMR IS GOOD TRAINING – BUT LIKE ALL TRAINING IT ONLY PREPARES THE MAN IN BASICS (LIKE GROUND/SIMULATOR TRAINING) HOW HE ACTS IN COMBAT SITUATIONS MAY BE ANOTHER MATTER, I.E., COOLNESS, COMMON SENSE, REACTION TIME, ETC. IT'S A GOOD TOOL BUT NOT ONE TO USE IN CHOOSING THE TOP 10-20% OF FIGHTER PILOTS. IT LEAVES OUT HEART-DESIRE, GUTS AND HEAD.

I THINK IT'S GREAT TRAINING – BUT WHEN THE GUY'S LIFE IS AT STAKE – WILL HE STILL PERFORM AS WELL ? IT'S LIKE PUTTING ALL YOUR MONEY ON A MOVIE CHARACTER IN AN ACTUAL STREET FIGHT.

FIGURE 2.8-1 PILOT OPINION ABOUT THE PERFORMANCE OF PILOTS IN AIR COMBAT MANEUVERING RANGES AND IN ACTUAL COMBAT

STATEMENT:
OUR MODERN HIGH PERFORMANCE AIR-TO-AIR COMBAT AIRCRAFT SHOULD BE PILOTED BY MEN WHO ARE CHOSEN BY STANDARDS THAT ARE MORE SELECTIVE THAN THOSE CURRENTLY USED.



SELECTED PILOT COMMENTS FROM THOSE MEN WHO AGREE OR STRONGLY AGREE:

AGREE AMERICAN FIGHTER ACE – BESIDES THE BASIC PHYSICAL AND MENTAL ABILITY TO COMPLETE TRAINING THE INDIVIDUALS CHOSEN SHOULD HAVE A STRONG DESIRE TO BE PILOTS!! GIVEN HEALTH AND NORMAL MENTAL ABILITY THE MEN WHO WANT TO BE WILL END UP THE BEST IN THE BUSINESS AND WILL KEEP AT IT LONGER THAN THOSE CHOSEN BY ANY YARDSTICK OF ACADEMIA.

AGREE AMERICAN FIGHTER ACE – (1) COMPLETE BACKGROUND INFORMATION; (2) COMPLETELY DISREGARD ABOVE IF CERTAIN PERSONALITY TRAITS ARE EVIDENT, I.E., HONESTY, INTEGRITY, DETERMINATION, PATRIOTISM, RESTRAINED EGOTISM; (3) DISREGARD EARLY SCHOLASTIC ACHIEVEMENTS AND CONCENTRATE ON CURRENT DESIRE TO ACHIEVE.

AGREE AMERICAN FIGHTER ACE – COST WOULD APPEAR TO BE A DOMINANT FACTOR IN SELECTING ONLY THE MAN WITH THE GREATEST POTENTIAL. THE PROBLEM SEEMS TO STEM FROM THE DEVELOPMENT AND EMPLOYMENT OF THE SELECTION CRITERIA. COULD IT BE MODIFIED TO ISOLATE AND IDENTIFY ON A "WHOLE MAN" CONCEPT AS OPPOSED TO ONE DESIGNED TO IDENTIFY PRIMARILY SCHOLASTIC ABILITY.

AGREE AIR NATIONAL GUARD – SPECIFIC CRITERION FOR SPECIFIC PILOT-TYPE OUTPUTS SHOULD BE ESTABLISHED. SOME, BUT NOT ALL, WOULD BE THE SAME (I.E., FORMATION FLIGHT APTITUDE).

AGREE RIVER RAT – A BETTER CRITERION IS TO CHOOSE PILOTS BASED UPON THE REQUIRED DUTIES. THE AIR-TO-AIR COMBAT AND TACTICAL GROUND ATTACK IN HEAVILY DEFENDED AREAS REQUIRE THE BEST PILOTS. SPECIALIZED PILOTS SUCH AS AIRLINE AND MAC PILOTS SHOULD BE SELECTED ON CRITERIA EMPHASIZING THEIR ABILITY TO BE GOOD INSTRUMENT PILOTS AND BE GOOD AT INTRA-PLANE CREW COORDINATION.

AGREE RIVER RAT – THE PRESENT SYSTEM SHOWS THAT THOSE WITH A COLLEGE DEGREE ARE MOST LIKELY TO COMPLETE TRAINING, THE TYPE OF DEGREE MAKES NO DIFFERENCE. IF THIS IS THE OVERRIDING CRITERION, I DISAGREE. SOME OF THE BEST STICK AND RUDDER PILOTS I HAVE EVER FLOWN WITH ENTERED TRAINING WITH A HIGH SCHOOL DIPLOMA. DURING THEIR CAREER THEY COMPLETED COLLEGE. I THINK A PERSON'S INNATE INTELLIGENCE IS IMPORTANT BUT HIS DESIRE TO BE A PILOT IS THE GREATEST DRIVE TO COMPLETE.

SELECTED PILOT COMMENTS FROM THOSE MEN WHO DISAGREE OR STRONGLY DISAGREE:

STRONGLY DISAGREE RIVER RAT – TO BE COST EFFECTIVE SELECTION MUST BE MADE ON ABILITY TO COMPLETE UPT.

STRONGLY DISAGREE AMERICAN FIGHTER ACE – AN EXPERIENCED INSTRUCTOR CAN PICK A DUD BY WATCHING HIS REACTIONS AS HE DRIVES A CAR (I PREDICTED MY NEPHEW WOULD WASH OUT OF FLIGHT TRAINING. HE DID). THERE MUST BE A TEST OF REFLEXES AND EMERGENCY DECISION MAKING.

STRONGLY DISAGREE AMERICAN FIGHTER ACE – USELESS IF THEY CAN'T COMPLETE THE PILOT TRAINING – IF THEY HAD DESIRE AND DETERMINATION I WOULD TRY TO BE PATIENT WITH THEM. SOME SLOW LEARNERS TURN OUT TO BE EXCELLENT.

DISAGREE AMERICAN FIGHTER ACE – IT IS IMPOSSIBLE TO PREJUDGE A PERSON'S INNER DRIVE – THAT FORCE THAT MOTIVATES HIM TO DRIVE ON IN, WHEN LOGIC WOULD CAUSE HIM TO HESITATE. THERE IS NO FEASIBLE WAY – YET, WHO WOULD VOTE ON SOMEONE THEY THOUGHT WOULDN'T COMPLETE THE TRAINING. OBSERVATION IS THE KEY – BUT, WHO REALLY GETS TO SEE THE SELECTEE IN ACTION?

DISAGREE NAVY MIG KILLER – MOTIVATION, ATTITUDE, AND PRECONCEIVED NOTION OF ONE'S SELF SHOULD BE DETERMINED. DOES THE PERSON WANT TO BECOME A FIGHTER PILOT? MOST ANYONE CAN, BUT FEW WANT TO BADLY ENOUGH TO BECOME VERY GOOD. THE TERM FIGHER PILOT IS MORE AN INSTINCT THAN DEFINITION. MANY PEOPLE WHO HAVE NEVER FLOWN AIRPLANES HAVE THE FIGHTER PILOT INSTINCT AND ATTITUDE.

FIGURE 2.9-1 PILOT OPINION CONCERNING SELECTION STANDARDS FOR PILOTS

2.10 SUMMARY

Questionnaires tapping pilot opinion on nine major policy issues were distributed to members of seven pilot organizations. These were members of the American Fighter Aces Association, Navy MIG Killers Association, Red River Valley Fighter Pilots Association, Air National Guard (in St. Louis, Missouri), Navy ACEVAL-AIMVAL Program, Air Force ACEVAL-AIMVAL Program, and the Aggressor Squadron at Nellis Air Force Base. Of the 735 questionnaires distributed, 373 (51%) were returned.

Results from the analyses of these responses were as follows; most pilots:

- o Disagreed with the concept of the universally assignable pilot (68%)
- o Agreed that a multi-track training system would be superior to the present system in which all pilots receive the same undergraduate training (61%)
- o Agreed that pilots should be dedicated to the air-to-air combat mission with no staff assignments (72%)[9]
- o Agreed that high performance air-to-air combat aircraft should be piloted by individuals with sufficient training sorties to make them combat ready at all times (89%)
- o Agreed that out-of-cockpit assignments will have an effect on air-to-air combat readiness (79%)
- o Agreed that there would be a relationship between performance in air combat maneuvering ranges and performance in air-to-air combat (65% and 54% on two related questions)
- o Agreed that air-to-air combat aircraft should be piloted by individuals chosen by more stringent selection standards than present ones (66%).

One of two remaining questions dealt with attitudes toward substituting simulator time for flight time. For some tasks (general procedures, instrument flying, and communications coordination), the pilots stated that they were willing to replace significant percentages of flight time with simulator time (41% to 44%). The final question dealt with budget cuts in proficiency training. More pilots stated that it would be better to have fewer pilots trained to top proficiency (33%) or a mixture of pilots - some at full and some at partial efficiency (41%) than to have a full complement of pilots trained to an intermediate level within a reduced budget (26%).

Overall, these data suggest that most of the pilots endorse major changes in training, management, and selection practices for the fighter pilot. This report addresses the question of how to improve fighter pilot selection procedures.

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[9] In a similar question which tapped attitudes toward the concept of a contract pilot, only 48% of the total pilot population agreed. However, 64% of current pilots sampled (i.e., excluding pilots from the American Fighter Aces Association) endorsed the concept of the contract pilot.

3.0 DATA CONCERNING THE ATTRIBUTES OF THE COMBAT EFFECTIVE

This section of our report establishes the attributes, i.e., the characteristics which have been associated with the combat effective in any combat role, and in particular, the characteristics and critical skills of the effective air-to-air combat pilot. In all, five major data sources have been used and are presented in the following sections: (3.2) Scientific studies of combat aviators in World War II, Korea, and Southeast Asia; (3.3) Scientific studies of nonaviator combat and combat surrogates with special emphasis on U.S. Army combat infantry in Korea; (3.4) U.S. Air Force and U.S. Navy pilot selection and flight training research from World War II to the present; (3.5) The fighter pilot selection programs of the governments of Germany and Japan during World War II and the current Israeli program; (3.6) Pilot inputs from biographical treatments of World War II fighter pilots, written illustrations of ace fighter pilots provided to us by 100 American aces, and data from specially prepared questionnaires which were distributed to some 800 American fighter pilots.

Using this elaborate data base, we will develop a composite "profile" of the characteristics and critical skills which are known or can be hypothesized to be related to air-to-air combat effectiveness (see Section 4). Before we begin our systematic review, however, we should take some time to develop a context within which to discuss combat effectiveness. In Section 3.1 we will look at a number of factors, such as the issue of opportunity for air kills, so that we may gain some understanding of the various complexities which abound in any analysis of this kind. Additionally, we will review what some famous soldiers have to say about why men fight.

3.1 A BRIEF ANALYSIS OF THE ISSUES OF OPPORTUNITY CHANCE, LUCK, SURVIVAL OF THE FITTEST, AND LEARNING/EXPERIENCE AS THEY RELATE TO FIGHTER PILOT COMBAT EFFECTIVENESS

During an interim presentation of this report, Erich Hartmann, with his 352 kills, was cited as a model of combat effectiveness. A member of the audience interrupted the briefing. "I wouldn't use Hartmann," he advised. "After all, there was a tremendous opportunity for kills on the Russian front; you can't use Hartmann."

From our perspective, excluding Erich Hartmann from the roles of the combat effective is extreme. Nevertheless, the issue of opportunity for air kills, as well as the related issues of chance, luck, survival of the fittest, and learning (experience) need to be considered in the analysis of the combat effective aviator.

The analysis of these issues that is presented here is largely heuristic; a relatively quick review to try to sort these issues out, and to present what conclusions appear to be warranted. Analysis of these issues also serves to create a "context" within which we should evaluate the combat effective air-to-air fighter pilot.

3.1.1 Opportunity - The issue of opportunity, the chance to engage the enemy, is clearly a decisive factor in the number of kills a pilot can possibly achieve. While some American and Allied pilots in World War II were able to achieve impressive kill records, it must be understood that the scores of American and Allied pilots were heavily influenced by opportunity. Germany and Japan kept many of their fliers on the front lines throughout the entire war. It is from these pilots, particularly the Germans, that we can see the truly amazing number of kills that can be achieved when opportunity is virtually unlimited. In Korea, as we shall soon see, opportunity was a factor which clouded some of the analyses which were conducted. In Southeast Asia, the limited number of opportunities for so many of our combat aviators made the analysis of that war's kill data, with respect to aviator qualities, virtually impossible.

The issue of opportunity as it is related to kill scores is dramatically underscored by the kill data from the United States, England, and Germany in both World War I and World War II for each of those countries' ten top aces. The summary records of these aces are shown in Figure 3.1-1. The ten top German pilots of World War II, some of whom were able to fly "from the first to the last," and many against Russian opponents flying largely ground support aircraft, were able to achieve a staggering 2,568 kills. According to Hans Ring, the German fighter pilot historian (Sims, 1967), a mere 300 German pilots destroyed 30,000 Russian aircraft. This most clearly reflects what highly accomplished combat pilots can achieve, given nearly limitless opportunities for kills.

9-984

	WW I	WW II
UNITED STATES	143	294
ENGLAND	562	314
GERMANY	497	2568

FIGURE 3.1-1 TOTAL SCORES OF TOP TEN ACES (Taken from Weiss, 1966)

German and Japanese policy apparently kept their fighter pilots in near continuous duty for the duration of the war (Constable and Toliver, 1968; Sakai, 1958), or until they were killed or disabled. Undoubtedly, some pilots were withdrawn from combat operations for other reasons (e.g., fatigue, instructor duty), but it appears that, except for very special pilots who were particularly distinguished (e.g., Galland,[1] Rudel,[2] and Sakai[3]), the Axis pilots were kept on continuous combat status.

The British and Americans pulled many of their high scoring pilots (e.g., Joe Foss) or rotated their pilots to noncombat roles following tours of a given duration or a specific number of missions. In addition to this fact, it may often have been the case that a nominal tour may not have resulted in many combat opportunities. As an example of the amount of flying it takes to make contact with the enemy, we looked at some representative records from the American Eighth Fighter Command operating against the Germans in World War II.

Official statistical engagement and kills summaries of the American Eighth Fighter Command operating against German aircraft from 1 July 1943 to 30 June 1944 indicate that the average encounter rate for American fighter pilots was only one per 25 combat sorties, with the kill rate per sortie being substantially below that (Johnson, 1944). American pilots, in this group at least, did not have the kind of numerous engagement opportunities which have been popularly imagined.

Figure 3.1-2 presents a monthly summary of data on these operations. Especially interesting are the comparisons between the columns summarizing total sorties per month, sorties involving combat, and enemy aircraft destroyed. We find that, over the 12 month period, it took nearly 94,000 sorties to produce just under 4,000 combat engagements to achieve 2306 aircraft destoyed.

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[1]Galland, of course, had become a national hero having scored nearly 100 Spanish and British kills by the end of the Battle of Britain. Hitler, in making Galland General of the Luftwaffe Fighter Command, ordered him off operational flight duty (Constable and Toliver, 1968). However, near the end of the war, Galland fell from grace with Hitler and returned himself to combat. Flying in his "Squadron of Experts," he added seven more kills in an ME-262 Jet. He ended the war with a total of 104 kills.

[2]Rudel, the unparalleled Stuka pilot, finished the war with 2530 operational sorties and a medal for valor especially designed by Hitler, and awarded only to Rudel (Rudel, 1958). Rudel was ordered by Hitler to stop flying more than once, but most seriously after he had lost a leg to anti-aircraft fire, while attacking a Russian tank with only one round of 30mm ammunition left. Rudel ignored the order and, incredibly, returned to combat flying in only six weeks.

[3]Sakai, Japan's top scoring pilot to survive the war was ordered off flying status after his 60th kill because of serious wounds, including the loss of an eye suffered in aerial combat over Guadalcanal (Sakai, 1958). Late in the war, he returned to combat and scored four more kills flying night missions over Japan.

In Korea, the total number of interceptor sorties flown compared with the total number of aircraft destroyed evidenced a ratio of about one kill per 88 sorties (Futrell, 1961). This is approximately one-half the kill per sortie rate obtained by the Eighth Fighter Command during World War II. It does suggest that, just as we found in World War II, American pilots did not typically have as great an opportunity to engage and destroy the enemy as might be imagined.

Strawbridge and Kahn (1955) present some interesting statistics on the Korean War:

> "From 14 December 1950 to 27 July 1953, the F-86s of the 4th F.I.W. met the MIG-15 in combat. During this period the 4th F.I.W. flew a total of 45,143 effective sorties, fired 2,963,000 rounds of ammunition, destroyed an estimated 484 enemy aircraft in aerial combat, and lost an estimated 78 F-86s to enemy aircraft....
>
> "The pilots of the 4th F.I.W. varied in both their combat performance and noncombat characteristics. However, before considering such differences, consider first the performance of a 'typical pilot,' one who possesses an attribute the measure of which lies in the middle 50 percent of the distribution of that attribute (the interquartile range). Twenty-five percent of the pilots have less of the attribute and 25 percent have more of the attribute than he does. In this sense the typical pilot is a statistical concept. The greater the number of attributes considered, the less likely that any one pilot is 'typical' with respect to all of them. Interest in the typical pilot centers chiefly in illustrating that these individuals were not the ones primarily responsible for victory over the enemy.
>
> "Jet fighter pilots have often been characterized as 'hungry tigers.' The following few statistics show how well the 'typical' tiger's appetite was satisfied. The typical pilot flew 41.5-102.4 combat missions in Korea. During all of these missions he sighted 1.9-12.6 enemy aircraft formations while flying as a leader and of these he was able to encounter 1.7-9.2 enemy aircraft. Of these aircraft 0.3-4.3 were fired upon, and he was credited with destroying 0.4-1.5. These relations are shown in Figure [3.1-3]. . .
>
> "In general,...the typical pilot was given little opportunity to contact the enemy. Combatwise he may be characterized as a pilot who flew most of his missions as a wingman, eventually flew a few missions as element or flight leader, and during these missions made limited contact with the enemy. It would appear that the typical

9-985

MONTH	AVERAGE PILOTS ASSIGNED	TOTAL SORTIES	AVERAGE HOURS PER SORTIE	SORTIES INVOLVING FIRING	SORTIES INVOLVING COMBAT	TOTAL COMBAT	CLAIMS (AIR ONLY)		
							DESTROYED	PROB. DEST.	DAMAGED
1943:									
JULY	274	2266	1.75	74	73	95	33	9	14
AUG	366	2124	1.97	128	126	169	54	10	33
SEPT	619	2945	2.34	93	92	119	40	1	10
OCT	710	2571	2.77	187	182	225	78	11	42
NOV	771	3955	2.80	264	259	334	106	27	44
DEC	865	4519	3.04	202	191	241	86	11	43
1944:									
JAN	1246	6061	3.15	369	343	453	172	26	80
FEB	1359	8131	3.39	654	556	724	276	25	148
MAR	1260	10175	3.79	984	591	827	387	33	135
APR	1358	12586	3.81	1717	470	656	334	23	95
MAY	1484	14374	3.99	1920	671	906	472	29	109
JUNE	1709	24035	3.75	4159	436	593	268	11	92
12-MONTH PERIOD		93742	3.50	10751	3990	5342	2306	216	845

FIGURE 3.1-2 THIS FIGURE SHOWS A MONTHLY SUMMARY OF OPERATIONS DATA FOR THE U.S. EIGHTH FIGHTER COMMAND. (Adapted from Official Eighth Fighter Command Document: Johnson, 1944)

hungry tiger was caged by the nature of the operational situation, with its structure of responsibility, and by the tactical situation. The effectiveness of the pilot's combat performance cannot be properly evaluated because he had too few contacts with the enemy." (pp. 9, 15-17)

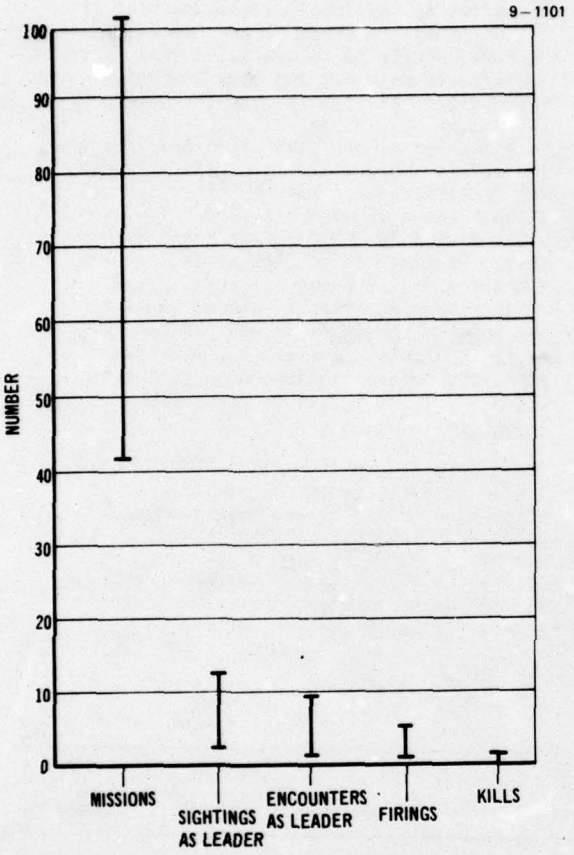


FIGURE 3.1-3 THIS FIGURE SHOWS THE INTER-QUARTILE RANGE OF NUMBER OF MISSIONS, SIGHTINGS AS LEADER, FIRINGS, AND KILLS FOR THE TYPICAL F-86 PILOT IN A TOUR IN KOREA (Adapted from Strawbridge and Kahn, 1955; See Text)

Two research groups, working under Air Force sponsorship during the Korean period, were conscious of the issue of opportunity in their analyses of pilot kills and aviator qualities. The first research group, Torrance, Rush, Kohn, and Doughty (1957), in conducting their research, selected 800 F-86 pilots who had at least 25 counterair missions. Of this group of 800, over half (53.5%) were unable to record a kill. At a global level, it may in fact be that 25 counterair missions did not constitute an adequate opportunity for these pilots when one considers that the overall kill per sortie ratio was about 1 to 88, and in light of Strawbridge and Kahn's (1955) "Hungry Tiger" characterization.

The other research group, Strawbridge and Kahn (1955), strongly objected to the use of kill records per se to identify combat effective pilots. On the one hand, their argument is somewhat overdrawn; of course the Korean War aces were combat effective. On the other hand, kills per opportunity would constitute a valuable measure of pilot combat effectiveness.[4]

As reviewed in Section 1.2.3, Strawbridge and Kahn (1955) analyzed the operational flight records of 520 pilots of the Fourth F.I.W. (Fighter Interceptor Wing) who flew in Korea. From this sample, the records of 69 pilots who had sufficient opportunity for MIG kills (15 or more encounters with the enemy while serving as an element leader) were selected for further analysis. Large individual differences were found. Some pilots converted 70 to 80 percent of their enemy encounters into firing passes, and 60 to 70 percent of their firing passes resulted in kills. Other pilots converted only 15 percent of their enemy encounters into firing passes and, in some instances, only 0 to 10 percent of their firing passes resulted in kills. This study and others conducted during the Korean War deserve special attention since the factor of opportunity is a major variable in the analysis of Southeast Asia air war records.

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[4]An interesting historical footnote concerning opportunity is the comparison between the records of German jet aces of World War II and those of their American counterparts in Korea. The Americans, during the three year Korean War, were able to produce 38 aces, the highest scoring among them gaining 16 victories. The German jet aces of World War II were able to accomplish nearly the same in the last months of World War II, but had greater opportunity to engage the enemy. They had 22 jet aces during this period and, coincidentally, their top scorer achieved 16 victories (Constable and Toliver, 1968).

While much can be learned from an analysis of the Southeast Asia air war, such as that represented by the Red Baron reports,[5] we feel that, for our purposes, only a limited amount can be gleaned from this source of information. The fact that literally thousands of U.S. pilots flew combat missions in Southeast Asia and only about 200 enemy aircraft were destroyed during the entire Southeast Asian conflict, makes opportunity an overriding factor.

In all, the Air Force accounted for 131 enemy air-to-air kills during the Southeast Asian conflict. For these kills, a total of 205 Air Force pilots and weapons systems operators (WSOs) were credited with one-half or more victories. Only 26 of that number were credited with two or more kills. The highest scorer, Captain Charles B. De Bellevue, a WSO, was credited with six kills (see Figure 3.1-4).

INDIVIDUALS	AIRCRAFT FLOWN	CREW POSITION	CREDITS
CPT CHARLES B DeBELLEVUE	F4D/E	WSO	6
CPT JEFFREY S FEINSTEIN	F4D/E	WSO	5
CPT RICHARD S RITCHIE	F4D/E	AC	5
COL ROBIN OLDS	F4C	AC	4
1LT ROGER C LOCHER	F4D	WSO	3
MAJ ROBERT A LODGE	F4D	AC	3
CPT JOHN A MADDEN JR	F4D	AC	3
LTC ROBERT F TITUS	F4C	AC	3
1LT MILAN ZIMER	F4C	P	3
1LT GEORGE H McKINNEY JR	F4D	P	2.5
LTC CARL G BAILY	F4D	AC	2
LTC LYLE L BECKERS	F4E	AC	2
CPT MAX C BRESTEL	F105D	P	2
MAJ PHILIP P COMBIES	F4C	AC	2
1LT STEPHEN B CROKER	F4C	P	2
1LT WILLIAM S HARGROVE	F4D/E	WSO	2
MAJ WILLIAM L KIRK	F4C/D	AC	2
CPT FREDERICK S OLMSTED JR	F4D	AC	2
MAJ RICHARD M PASCOE	F4C	AC	2
CPT LAWRENCE H PETTIT	F4D	WSO	2
CPT EVERETT T RASPBERRY JR	F4C/D	AC	2
MAJ GARY L RETTERBUSH	F4E	AC	2
CPT DARRELL D SIMMONDS	F4D	AC	2
CPT CALVIN B TIBBETT	F4D/E	AC	2
1LT STEPHEN A WAYNE	F4C	P	2
CPT NORMAN E WELLS	F4C	P	2

FIGURE 3.1-4 AIR FORCE PERSONNEL WITH TWO OR MORE AERIAL VICTORIES IN SOUTHEAST ASIA (Taken from U.S. Air Force Combat Victory Credits Southeast Asia, 1974)

Many pilots who flew large numbers of missions in Southeast Asia probably never encountered enemy fighter aircraft. Because of the issue of opportunity, many of the pilots from the Southeast Asian conflict that we interviewed did not believe that a pilot with one air kill significantly stood above other pilots; the other pilots, may not have had an opportunity for a kill. Furthermore, it is believed by some Air Force and Navy pilots that certain selected pilots were purposely given every conceivable opportunity to achieve air kills in order that their respective services could produce an ace.

We cannot sum it up as well as one seasoned fighter pilot commander has done in his response to our questionnaire. Here is his feeling on the matter:

> "I could relate events illustrating the qualities possessed by men who would have been 'top scorers' had opportunity existed. They flew and fought over North Vietnam and were as good or better than anyone I had flown with in the previous 20-odd years."

3.1.2 Chance - One of the perennial questions which is asked concerning flight kill records is whether or not they could be accounted for by chance.[6] Considering only decisive encounters, chance is defined as having a .5 probability of a kill or being shot down.

Figure 3.1-5 summarizes the flight kill records of 2156 pilots of the eighth Air Force Fighter Command who had at least one-half air-to-air kill against the Germans in World War II. An additional 749 pilots had air-to-ground kills, but no air-to-air kills. As noted in the Introduction and the Executive Summary, the data shown in this figure underscore the remarkable achievement of a relatively small group of pilots.

---

[5] For a listing of the Red Baron reports see Figure 3.2-1.

[6] Ordinarily, this issue is focused on high scoring aces; after all, the argument goes, with enough pilots someone is bound to make a big score (by chance). While we will look at this question in particular, we will also look at data that relate to two other questions which could involve "chance" explanations. They are (1) do fledgling pilots do worse than chance? and (2) can overall differences in kill ratios between opponent countries be "explained" by chance?

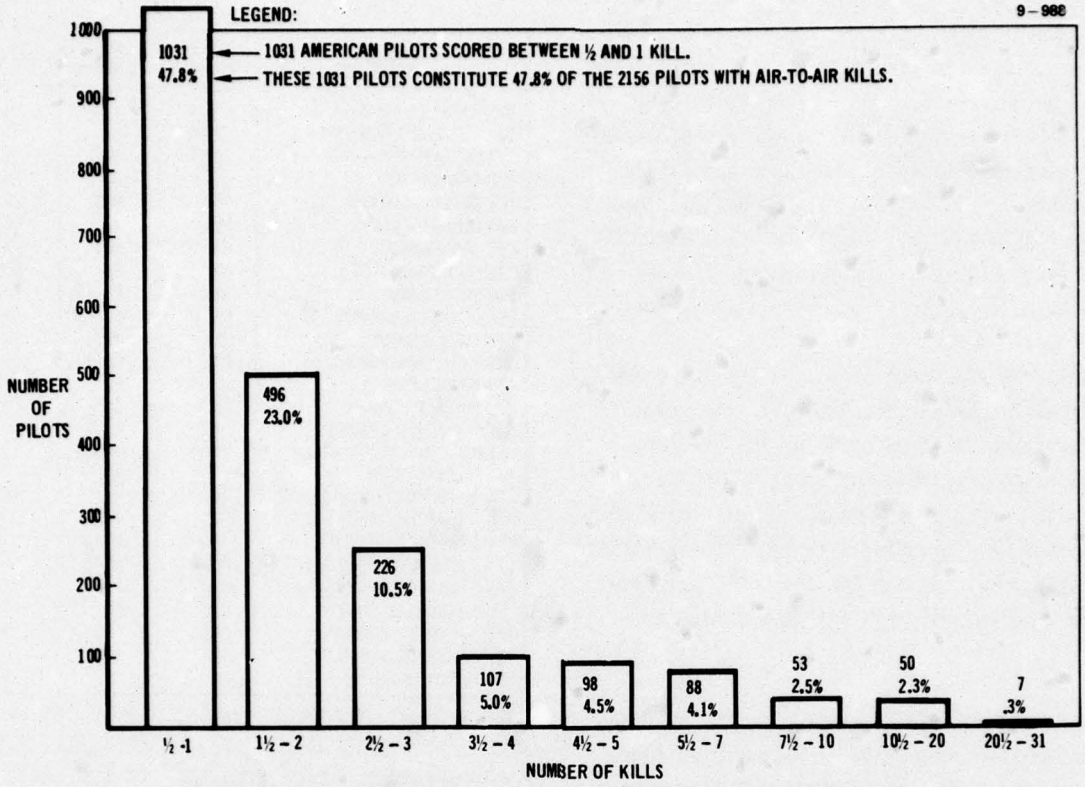


FIGURE 3.1-5 THIS FIGURE SHOWS THE NUMBER OF EIGHTH AIR FORCE PILOTS WITH AIR-TO-AIR KILLS RANGING FROM 1/2 KILL TO 31 KILLS AGAINST THE GERMANS IN WORLD WAR II. (From Final Report of Assessed Fighter Claims Against Enemy Aircraft, August 1942 - April 1945; Published September, 1945)

Weiss (1966) has performed an analysis of air-to-air combat data which are generally considered most relevant to the issue of survival of the fittest/learning. While we will review his work in more detail in subsection 3.1.4, his analysis is very relevant in considering the chance issue. According to his analysis, fifteen percent of the pilots in his sample had a better than even chance of surviving their first decisive encounter (decisive means that one of two opponent aircraft in an encounter is destroyed). Pilots who survived their first few decisive encounters, on the other hand, had a much better than "chance" probability of winning subsequent encounters.

Constable and Toliver (1968), in their review of German aces, have presented some interesting "Tops and Firsts" for the Luftwaffe fighter pilots of World War II. Figure 3.1-6 is adapted from their excellent book; inspection will show what some aviators are able to accomplish given the opportunity. The kill records of high scoring aces from all nations, but particularly from Germany, in World War II, appear so improbable that chance alone can be ruled out by any reasonable person.

Figure 3.1-7, again adapted from Constable and Toliver (1968), shows the distribution of air kills for the 107 German pilots of World War II with more than 100 kills. These records are truly astonishing whether they are chance or not. From among this group, taking a single example, we find the German pilot, Marseille,[7] achieving 150 aerial kills over

[7]Constable and Toliver (1968, p. 100) report that Marseille was forced to bail out some six times as a result of his battles prior to his North African combat.

9-989

TOPS AND FIRSTS – LUFTWAFFE, WORLD WAR II	
TOP ACE	
MAJOR ERICH HARTMANN	352 VICTORIES
TOP NIGHT FIGHTER ACE	
MAJOR HEINZ SCHNAUFER	121 VICTORIES
FIRST ACE TO EXEED BARON MANFRED VON RICHTOFEN'S WORLD WAR I SCORE OF 80	
CAPTAIN WERNER MOELDERS	
FIRST TO SCORE 100 VICTORIES	
MAJOR WERNER MOELDERS	15 JULY 1941
FIRST TO SCORE 250 VICTORIES	
MAJOR WALTER NOWOTNY	14 OCTOBER 1943
MOST KILLS SCORED IN A SINGLE DAY	
MAJOR EMIL LANG	18 VICTORIES
MOST KILLS ON A SINGLE MISSION (SORTIE)	
MAJOR ERICH RUDORFFER	6 NOVEMBER 1941 13 VICTORIES
MOST KILLS SCORED ON THE WESTERN (INCLUDES MEDITERRANEAN) FRONT	
CAPTAIN HANS-JOACHIM MARSEILLE	158 VICTORIES
MOST KILLS SCORED ON THE RUSSIAN FRONT	
MAJOR ERICH HARTMANN	352 VICTORIES
BEST KILL AVERAGE PER SORTIE FLOWN (DAY FIGHTERS)	
LIEUTENANT GUENTHER SCHEEL 70 MISSIONS 71 VICTORIES	(RUSSIAN FRONT)
TOP FIGHTER ACE FOR NUMBER OF FOUR-ENGINED AIRCRAFT SHOT DOWN (DAY FIGHTERS)	
LIEUTENANT HERBERT ROLLWAGE	102 VICTORIES (44 OF THEM FOUR-MOTOR BOMBERS)
TOP FOUR-ENGINE KILLER (NIGHT FIGHTERS)	
MAJOR HEINZ SCHNAUFER	121 VICTORIES (MOSTLY FOUR-ENGINE)
TOP JET ACE (ME-262)	
MAJOR HEINZ BAER	16 VICTORIES

FIGURE 3.1-6 "TOPS" AND "FIRSTS" FOR LUFTWAFFE PILOTS IN WORLD WAR II (Adapted from Constable and Toliver, 1968)

the British in North Africa without ever being reported downed (Constable and Toliver, 1968; Sims, 1967). If we were to assume equal probabilities of obtaining a kill or being shot down (which is hardly a tenable assumption in light of Weiss' [1966] findings), this achievement would have a probability of occurrence of (1/2)150.

Figure 3.1-8 shows the kill records of 800 U.S. Air Force F-86 pilots against MIG-15 opponents in Korea. Again we see a relatively small number of pilots achieving the lion's share of the kills. *Could this distribution have occurred by chance?*

The overall kill statistics from Korea were examined to see if they could be "explained" by chance. Figure 3.1-9 summarizes the kill ratios

9-990

NAME	RANK	VICTORIES
HARTMANN, ERICH	MAJ.	352
BARKHORN, GERHARD	MAJ.	301
RALL, GUENTHER	MAJ.	275
KITTEL, OTTO	1ST. LT.	267
NOWOTNY, WALTER	MAJ.	258
BATZ, WILHELM	MAJ.	237
RUDORFFER, ERICH	MAJ.	222
BAER, HEINRICH	LT. COL.	220
GRAF, HERMANN	COL.	212
EHRLER, HEINRICH	MAJ.	209
WEISSENBERGER, THEODOR	MAJ.	208
PHILIPP, HANS	LT. COL.	206
SCHUCK, WALTER	1ST LT.	206
HAFNER, ANTON	1ST LT.	204
LIPFERT, HELMUT	CAPT.	203
2 (PILOTS)		190 – 199
4		180 – 189
6		170 – 179
2		160 – 169
6		150 – 159
4		140 – 149
18		130 – 139
14		120 – 129
15		110 – 119
21		100 – 109

FIGURE 3.1-7 THIS FIGURE SHOWS THE SCORES OF THE 107 LUFTWAFFE ACES WITH ONE HUNDRED OR MORE AERIAL VICTORIES IN WORLD WAR II. THE FIFTEEN PILOTS WITH 200 OR MORE KILLS ARE LISTED BY NAME. TWO PILOTS SCORED BETWEEN 190 AND 199 KILLS; 21 PILOTS SCORED BETWEEN 100 AND 109 KILLS. (Adapted from Constable and Toliver, 1968)

9-992

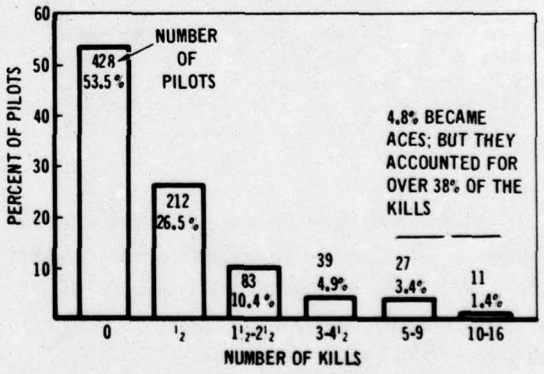


FIGURE 3.1-8 THIS FIGURE SHOWS KOREAN WAR MIG-15 KILLS FOR 800 USAF F-86 PILOTS EACH OF WHOM HAD AT LEAST 25 COUNTER-AIR MISSIONS (Drawn from Statistical Kill Summary Shown in Torrance, ET AL, 1957)

which were evidenced in Korea during quarterly time periods from July 1950 through July 1953. When only F-86 action is examined, however, the

9-986

TIME PERIOD	ENEMY AIRCRAFT DESTROYED	USAF AIRCRAFT DESTROYED	ROUNDED RATIO ENEMY DEST/ USAF DEST
JUL-SEPT 1950	32	5	6/1
OCT-DEC 1950	17	4	4/1
JAN-MAR 1951	17	4	4/1
APR-JUNE 1951	40	11	4/1
JULY-SEPT 1951	30	10	3/1
OCT-DEC 1951	88	31	3/1
JAN-MAR 1952	87	13	7/1
APR-JUNE 1952	97	18	5/1
JULY-SEPT 1952	116	15	8/1
OCT-DEC 1952	83	13	6/1
JAN-MAR 1952	98	8	12/1
APR-JUNE 1952	163	5	33/1
JULY 1953	32	2	16/1
TOTAL	900	139	7/1

FIGURE 3.1-9 USAF CLAIMS/KILLS AND LOSSES IN KOREAN WAR AIR-TO-AIR COMBAT (Adapted from Bilikam and Frick, 1970)

overall kill rate proves to be closer to 10 to 1 than the 7 to 1 summary rate shown for all air combat in Korea. According to the official Air Force history of the air war in Korea:

> "In aerial combat Sabre pilots claimed to have destroyed 810 enemy planes, including 792 MIG-15 fighters. In air-to-air combat the Far East Air Force lost a total of 139 aircraft, including 78 Sabres. The Sabre pilots thus maintained a ten-to-one margin of victory over the MIG-15 jet fighters - the best planes which the Communists displayed in action in Korea." (Futrell, 1961, p. 649)

Using the MIG-15 and Sabre kill data (792 MIG kills versus 78 Sabres), we conducted two conventional statistical operations (Chi-square and a simple binomial expansion - see Appendix 3.A.1) to determine if the chance "explanation" could be rejected. Both statistical procedures indicate that we can very confidently rule chance out as an explanation of the outcome of the Korean air war battle between Sabre and MIG-15.

Inasmuch as the highest scoring Air Force ace in Southeast Asia claimed only six kills, and since the total number of kills by both services was only about 200, it might appear that chance could be used to explain these kill records. However, when we subjected the Air Forces' 2.5 to 1 kill ratio to statistical analysis (using 131 enemy destroyed as a base) we find that the chance "explanation" can be rejected with considerable confidence (Chi square and simple binomial expansion were used, see Appendix 3.A.2).

We were able to gather some pilot opinion data concerning the issue of chance and luck. As part of the pilot questionnaire, we asked the pilots the question shown in Figure 3.1-10. The histogram in Figure 3.1-10 shows the pilot responses to this question. Unfortunately, the way we presented the question appears to us now to be vague. Additionally, it would appear that some of the pilots, recently conditioned by the Southeast Asian experience, may have also misinterpreted the question. About all we can say is that the clear majority of pilots disagree that air kills are a matter of chance or luck.

9-1104

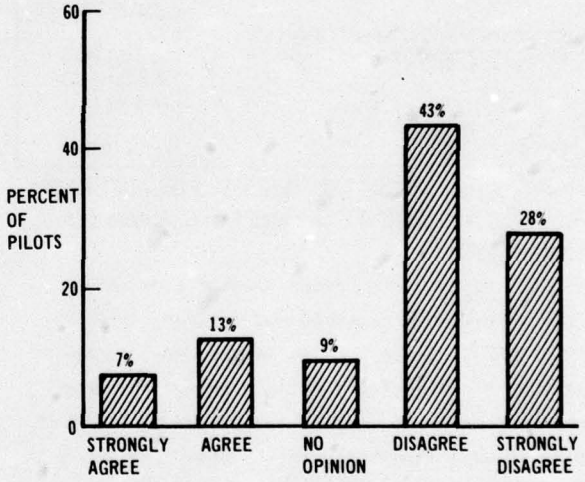


FIGURE 3.1-10 THIS FIGURE SHOWS PILOT OPINION CONCERNING CHANCE AND LUCK AS THEY RELATE TO AIR KILLS

3.1.3 Luck - Luck is used in the sense of living through potentially catastrophic combat incidents, not so much by positive action, but by fortuity. Any number of anecdotal incidents have been reported by Allied and Axis pilots of World War II attesting to this phenomenon. Both Sakai, the highest scoring Japanese pilot to survive the war (64 kills), and Hartmann, the highest scoring German pilot (352 kills), admit that by all rights they should have been killed in their very first combats (Sakai, 1958; Toliver and Constable, 1970). What is clear from World War II is that early combat engagements resulted in very high pilot attrition. It seems assured that many potential aces are lost during that period because of their inexperience. In a well known article, Weiss (1966) has presented data which give a very grim picture of a fledgling pilot's chances of surviving his first few decisive combat enagements. Novices are very poor risks, indeed, and have a poor chance of "surviving even their first encounter" (Weiss, 1966). Significantly, those pilots who survive their first few (5 to 8) decisive encounters then evidence a remarkably high probability of surviving subsequent decisive encounters (about a .98 chance of survival).[8]

Two important points should be made with regard to these concepts. If we send pilots to combat without adequate, specialized, air-to-air combat training against an opponent with good fliers, then we must anticipate high attrition, poor combat effectiveness, or both, to occur. If, however, Weiss' analysis is correct and we can select and train our pilots for high air-to-air ability, then we can expect to obtain high survivability and sustain exceedingly high kill ratios against any opponent who does not have an equally effective selection, training, and pilot management system.

Certainly, some luck is involved in combat effectiveness scores. The only way that we can sensibly explain the kill statistics coming out of World War II (particularly for the Luftwaffe) is to invoke the notion of kill ratio and luck. The German fighter pilots of World War II produced some remarkable statistics with regard to kill ratio (i.e., number of kills: number of times shot down). A sampling is shown in Figure 3.1-11.

9-998

PILOT	VICTORIES	MODIFIED KILL RATIO
MAJ. ERICH HARTMANN	352	20:1
MAJ. GERHARD BARKHORN	301	33:1
CAPT. HANS-JOACHIM MARSEILLE	158	150:0
CAPT. HELMUT LIPFERT	206	13:1
MAJ. ERICH RUDOFFER	222	10:1
MAJ. GEORGE EBER	36	2:1
OBLT KURT WELTER	33	1.5:1

FIGURE 3.1-11 THE WORLD WAR II RECORDS OF SELECTED GERMAN FIGHTER PILOTS USED TO ILLUSTRATE THE KILL RATIO CONCEPT (Drawn from Sims, 1951 and Constable and Toliver, 1968)

Erich Hartmann, Germany's top scorer, while achieving 352 victories, was himself forced down some 18 times, roughly a 20:1 kill ratio.[9] The largely unheralded Gerhard Barkhorn achieved 301 victories against the Russians while being forced down about nine times. We have already mentioned Marseille, Germany's top scorer against the British, who shot down 150 of his opponents in North Africa without being downed.[10]

Two other high scorers present interesting kill ratio statistics. Helmut Lipfert, flying against the Russians, scored 203 victories but was shot down 15 times (13 by ground fire). Erich Rudoffer, who divided his 222 kills between East and West, was shot down 16 times and forced to bail out another 9 times for a kill ratio of about 10:1 (Toliver and Constable, 1970).

---

[8]The Weiss data are treated in more detail in Section 3.1.4.

[9]According to Hartmann's biographers (Toliver and Constable, 1970), 16 of the 18 times that he was forced down resulted from damage to his plane caused by exploding Russian aircraft that he was attacking.

[10]Interestingly, a large number of Germany's top scoring pilots did, in fact, survive the war. Both scorers with over 300 kills (Hartmann and Barkhorn) are among this group and played significant roles in the rebuilding of the Luftwaffe. Marseille died during the war in a freak air accident in North Africa.

All of these high scoring German pilots demonstrated kill ratios of 10:1 or better with Hartmann exhibiting about a 20:1 ratio; and some, Marseille (150:0) for example, demonstrating astonishingly high kill ratios. Some pilots achieved high kill ratios which, when augmented by luck, resulted in high scores, that is, high combat effectiveness.

Pilots at the end of the kill ratio spectrum also achieved remarkable records. For example, Germany's George Eber, who demonstrated a 2:1 kill ratio, downed 36 bombers but was shot down 17 times and wounded on 12 occasions (he survived the war). Finally, one more German pilot who pushed his luck was Kurt Welter who finished the war with 33 kills (22 of them were bombers). On his first 11 sorties, he scored 14 kills but was shot down 9 times, a kill ratio of about 1.5:1.

Pilot lore can be used to support the opinion that pilots, in general, acknowledge some element of luck in living through aviation incidents, particularly those which are clearly out of their individual control - "every safe landing is a good landing."

While incidents of luck (surviving to fight again) can be quoted from Southeast Asia as well as Korea (remember the famous photo of America's triple ace, Joe McDonnell, being rescued from the sea by helicopter, following a forced landing?), it is not really "required" in either case.

Because of the "relatively" small number of high scoring pilots in Korea, and particularly in Southeast Asia, the concept of luck does not "have to be invoked."

3.1.4 Survival of the Fittest or Learning/Experience?[11] Weiss (1966) whom we have already mentioned, was also struck by the fact that it was the relative few who are doing the overwhelming amount of damage to the enemy. He hypothesized that fighter force strength is related to the performance of a few top pilots rather than the size of the force.

Weiss (1966) developed his thesis by summarizing empirical data on the probability of being killed in a decisive engagement from large sample statistics from two wars; Richtofen's Jagdgeschwader[12] No. 1, and American pilots serving with the French (including the Lafayette Escadrille) in World War I, and Jagdgeschwader JG 26 in World War II. The data are shown in Figure 3.1-12.

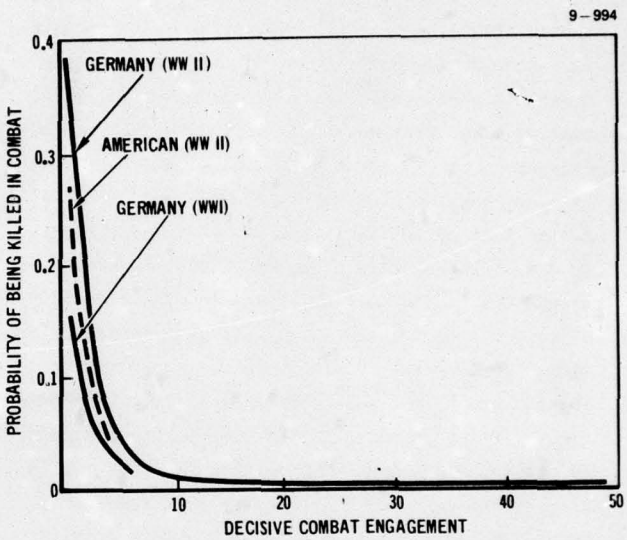


FIGURE 3.1-12 THIS FIGURE SHOWS FIGHTER PILOT LOSS RATE VS KILL SCORE FOR THREE LARGE FIGHTER GROUPS. IMPORTANTLY, THESE DATA SHOW ONLY THE OUTCOME OF DECISIVE ENCOUNTERS (Drawn from Weiss, 1966)

To Weiss:

"The initial almost vertical drop in probability of being killed between decisive combats one and five was completely unexpected.

---

[11]We found a consensus of belief that both survival of the fittest and experience are important factors. The reader should not dismiss the "consensus of the data" because of "exceptions to the rule." For example, one ace (J. F. Sutherland; Personal Communication) reported that one of his fellow Navy pilots who had gone through an exhaustive pre-World War II "selection" process, and was an exceptionally skilled aerobatic pilot (i.e., "the fittest") was killed in his very first combat. On the other hand, we have seen inexperienced pilots score big on their first combat mission.

[12]Weiss (1966) defines chance as a .5 probability of winning or losing a decisive air-to-air encounter. Jagdgeschwader is the German word for Fighter Wing and is abbreviated as JG. These units were usually made up of from 108 to 144 aircraft.

> "The value of about 0.02 [i.e., a two percent chance of being killed in any decisive engagement] in the range 10 - 30 [decisive encounters] is consistent with similarly computed values for American aces in World War II and Korea which fell in the range of 0.01 to 0.03."

Values in the same range are also shown by Weiss in Figure 3.1-13 except for German aces with between 31 and 197 kills; for these pilots, the probability of being killed in any decisive engagement is .009.

9-995

SERVICE		RANGE OF SCORES	PROBABILITY OF BEING KILLED IN ANY DECISIVE ENGAGEMENT
UNITED STATES	- EIGHTH AF/EUROPE	10-28	0.015
UNITED KINGDOM	- RAF	20-38	0.024
GERMANY	- JG-26	10-30 31-197	0.018 0.009

FIGURE 3.1-13 THIS FIGURE SHOWS THE EMPIRICAL PROBABILITY OF BEING KILLED IN ACTION AS A FUNCTION OF NATION AND RANGE OF SCORES (See Text) (Taken from Weiss, 1966)

A quick analysis on a statistical summary of World War II Allied aces prepared by Hess (1968) indicated that aces with five or six kills had a .032 probability of being killed in subsequent decisive engagements while aces with 15 or more kills had a .007 probability of being killed in subsequent decisive encounters (see Figure 3.1-14).

9-996

PILOTS WITH GIVEN NUMBER OF KILLS	NUMBER OF PILOTS	NUMBER OF PILOTS KIA	PERCENT OF PILOTS KIA	TOTAL NUMBER OF DECISIVE ENGAGEMENTS FOR THESE PILOT GROUPS	PERCENT OF PILOTS KIA PER DECISIVE ENGAGEMENT
5 OR 6 KILLS	255	66	26%	2043	3.2%
15 OR MORE KILLS	88	12	13.7%	1743	0.7%

FIGURE 3.1-14 THIS FIGURE SHOWS THE DIFFERENCE IN SURVIVAL FOR TWO GROUPS OF ALLIED PILOTS IN WORLD WAR II; SEE TEXT (Drawn from a Statistical Summary of the Records of Allied Pilots, Hess, 1968)

In accounting for these data, Weiss (1966) favored survival of the fittest rather than learning:

> "An improvement factor of twenty in five 'trials by combat' seems less likely to the writer [Weiss] than the hypothesis that. . . [Figure 3.1-12]. . . represents the survival of the fittest."

Weiss (1966) developed a model to estimate the impact of being able to send only "Hawks" (i.e., good pilots; potential aces) to battle. Several assumptions were made - pilots can be categorized as either Hawks or Doves; Hawks, not identifiable before combat, represent ten percent of replacement pilots; air combat engagements are one-on-one; the probability of having Hawks, Doves, or both, in each combat engagement is proportional to their representation in the two forces; Hawks always win against Doves, Hawks are equivalent, and no loss results from combat between Doves; aircraft and pilots are replaced as they are lost and forces are equal; and pilots can survive aircraft losses with certain specified probabilities. Based upon these assumptions, Weiss concluded:

> "If the precombat training and screening process delivers only 'Hawks' to one side, that side may have a 10:1 sustained exchange ratio, at all times."

The combat kills and attrition data presented by Weiss (1966) have been used by other analysts in developing "position papers" concerning the effect of learning in achieving air combat kills. For example, Bilikam and Frick (1970), operations analysts in the Air Force's Aeronautical Systems Division, produced a preliminary paper aimed at ". . . establishing whether or not combat data from World War II, Korea, and SEA showed promise of establishing the existence of a learning effect in pilots who are continually engaged in air-to-air combat." While their preliminary report concluded that the ". . . evidence was inconclusive. . . ," they make some observations which are worth noting.

Using descriptive statistical summaries by Futrell (1960) on the air war in Korea, Bilikam

Frick (1970) found some suggestion of a learning phenomenon in that, ". . . 68 percent of the pilots who destroyed MIGs were over 28 years old, and that this was significantly greater than the age of the overall population of pilots." Additionally, they use Korean War statistics (see Figure 3.1-9), which summarize the results of air-to-air encounters, to show a trend toward U.S. improvement in kill ratio[13] which they account for by several alternative explanations:[14]

> "One could argue that the Korean War data, which shows a trend towards increasing USAF superiority, would support the hypothesis that a learning effect is present. However, one could also have such a trend if "survival of the fittest" were the predominant effect. Such an effect would cause an enrichment of the population of good pilots as time elapsed which would mean that combat scores of the pilot population as a whole would get better.
>
> "To fully test the hypothesis of a learning effect in air-to-air combat will probably involve a two-fold approach. One would be analyses of combat data on individual pilots and the other would be to test for a learning effect under controlled experimental conditions. This latter approach is necessary in order to have subjects remain "alive" to determine if they gained experience from the previous encounter.
>
> "One's intuition suggests that probably both effects, survival-of-the-fittest due to innate skills and learning by exposure to repeated combats, are present. There is also a third effect which comes to mind, and that is, the interaction with enemy skill level, and whether that skill level changes with time. This additional consideration is an argument against relying exclusively on combat data to test the hypothesis of learning, because there are so many uncontrolled factors present; one does not really know what is causing the variations in fraction of pilots surviving. Controlled laboratory conditions, i.e., simulation, may be the only answer." (pp.4-5)

This observation by Bilikam and Frick, in 1970, was well taken. Today, however, they might well add controlled air combat maneuvering ranges to the list of potential (testing) tools that might be used to gain insight into these problems.

In-cockpit experience (undoubtedly confounded with flight position-opportunity) is evidenced in Southeast Asia, as was the case in Korea. For example, Anderson (1972) has reported that 12 out of 13 MIG kills in Vietnam were accomplished by pilots with an average of 2,200 hours of like aircraft background and with an average age of 35 years. Also, recently declassified evidence from the Red Baron reports (deLeon, 1977) indicates, once again, that during at least one phase of the war, cockpit experience is positively related to kills.

However, the most dramatic evidence of the effect of specialized air-to-air training (learning/experience) comes from Navy pilot kill records in Southeast Asia. Prior to the introduction of the Navy's Top Gun school where pilots flew against dissimilar aggressor aircraft, their kill ratio was 2.5 to 1; after Top Gun the kill ratio jumped to 12.5 to 1 (deLeon, 1977). While this improvement may be due to selection practices of sending only the "better" pilots to Top Gun, or indeed to changes in the air war itself, it is usually seen as evidence for the efficacy of this type of specialized training.

It is just common sense that highly relevant training in an air combat surrogate ("give the pilot his first eight encounters where he won't be killed") will help pilot effectiveness. The more compelling issue is whether that training will be sufficient to produce truly combat effective pilots. It may be that this (and even more extensive) training combined with the improved pilot selection protocols will be required.

When we asked some of the Air Force pilot instructors[15] at the Air Combat Maneuvering (Range) School at Nellis AFB about this issue, they reported that . . . "New pilots in the advanced program who

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[13]According to a summary of Gen. Momeyer (1974), no such significant trend was evidenced by Air Force pilots in Southeast Asia.

[14]Futrell (1961) sees the dramatic improvement in kill ratio during the last nine months of the war (see Figure 3.1-9) resulting from the withdrawal of Russian pilots from the air war.

[15]Personal communication.

do well in their first flights not only continue to be better but, in fact, generally improve their lead over the other pilots."

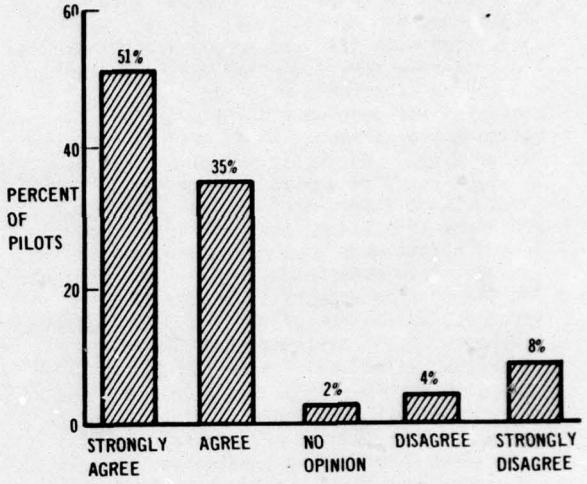
It is appropriate to ask what the pilots themselves feel concerning the "survival of the fittest" and learning issues. Figure 3.1-15 indicates the pilot responses to our questionnaire concerning learning and survival of the fittest. The histogram in Figure 3.1-15A indicates that most of the pilots (86 percent) agree that learning, indeed, does take place through combat experience. The accompanying histogram (Figure 3.1-15B) concerning the issue of survival of the fittest indicates that the clear majority of pilots (53 percent) agree that there is also a survival of the fittest phenomenon going on.

The factors which chronically make analysis of air-to-air combat kill data (regarding U.S. aviator qualities) difficult were summarized in the thorough study of these issues, by Strawbridge and Kahn (1955).

> "All fighter pilots were not equally effective in Korean combat. Most pilots destroyed very few enemy aircraft; a few pilots destroyed many aircraft. These differences in effectiveness were partially the result of the operational and tactical situations and partially the result of differences in individual abilities among the pilots.
>
> "From an operational viewpoint the older, higher ranking pilots with the most flying and prior combat experience were chosen to fly as flight or element leaders on most of their counterair missions to MiG alley. Younger, less experienced pilots flew proportionately more missions as wingmen. Consequently the leaders experienced more of all phases of combat and, because of this considerable opportunity, scored more enemy kills. Although these pilots had the most opportunity to contact the enemy there is no basis for believing that they were basically any more effective than pilots who were chosen less often to fly a lead position. There is no evidence to indicate that the pilots who experienced 15 or more encounters with the enemy were able to maneuver into firing position or fire more accurately than pilots who experienced fewer encounters with the enemy. Nor is there any evidence furnished by the pre-pilot-training tests that discriminates these two groups. The Training Command would consider most of the pilots who flew in Korea better than average risks to complete the training program successfully.
>
> "Among those pilots who had sufficient contact with the enemy (15 or more encounters), considerable variability in effectiveness is noted. Some pilots were [very good, and

EVIDENCE FROM WORLD WAR II AND LATER CONFLICTS INDICATES THAT A COMBAT FIGHTER PILOT'S CHANCES OF SURVIVAL ARE DRAMATICALLY IMPROVED IF HE SURVIVES HIS FIRST FIVE AIR-TO-AIR ENCOUNTERS. THIS IS A REFLECTION OF:

A. THE PILOT'S LEARNING THROUGH EXPERIENCE



B. A "SURVIVAL OF THE FITTEST" PHENOMENON. THE POORER PILOTS ARE SHOT DOWN

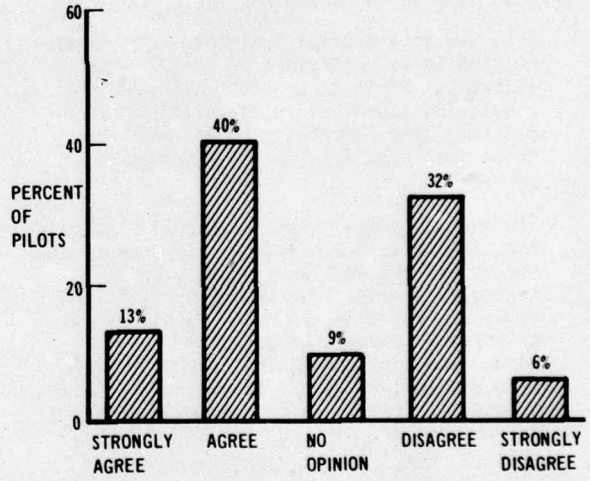


FIGURE 3.1-15 THIS FIGURE SHOWS PILOT ATTITUDE CONCERNING LEARNING AND "SURVIVAL-OF-THE-FITTEST" PHENOMENA DURING EARLY COMBAT ENCOUNTERS

were able to convert about one-half of their encounters into kills . . . some pilots were poor and recorded no kills]. . .

"Since considerable interest is attached to understanding the basis for individual differences in combat performance, a number of selected non-combat variables have been correlated with selected combat variables. These correlations suggested that age, rank, and flying experience were the significant variables influencing a pilot's flight assignment as leader. These leaders showed marked degrees of Physical Aggressiveness and Risk and Strategy as measured by Torrance's [1957] "Life Experience" scales. However, there are indications that these more experienced pilots were somewhat more cautious than younger, less experienced men. The amount of jet flying time appears to be one of the strongest variables influencing combat effectiveness. It is presumed that the young, aggressive pilot well trained in jet aircraft would be the most effective pilot in this type of combat. Evidence is offered which suggests that several of Torrance's scales show promise of having predictive value in measuring combat effectiveness. Physical Aggressiveness and Parental Striving are shown to influence combat effectiveness. Testing the Limits, Childhood Neurotic Behavior, and Social Participation also show promise in this direction.

"The use of pre-pilot-training tests shows no promise as predictors of combat effectiveness. While these tests are valid in predicting pass-fail in the pilot training program, they apparently do not measure those qualities necessary for success in combat.

"In the aggregate, these points all indicate that the qualities necessary for success in combat are not well understood. While flying experience, particularly jet flying time, plays a role, superior combat effectiveness is founded on much more basic mechanisms, as implied in Torrance's scales. It seems evident that reliable prediction of combat effectiveness must await the development of much more subtle psychological and physiological tests." (pp. 71-72)

We've underlined the last few words of Strawbridge and Kahn's (1955) summary because we would make an important distinction - we don't think the tests will be more subtle, but rather, they should be based upon selection tests of what can reasonably be presumed to underlie air combat effectiveness. Furthermore, these tests should be comprehensive (i.e., test all of the factors which are considered important) and, should be designed to be more powerful and demanding so that they have the capability of discriminating among the pilot candidates who can "pass" the various components of selection tests that are currently employed.

Before we begin our systematic search for the factors which underlie combat effectiveness, a brief review of what some famous soldiers tell us about combat effective men is in order to add perspective to the problem.

3.1.5 What Some Famous Soldiers Tell Us about Combat Effective Men - What is the human ingredient that distinguishes the coward from the gallant soldier, the combat effective from the ineffective, the man who will fight from the man who will not fight?

S. L. A. Marshall, a World War I veteran, and professional military historian had an unparalleled opportunity to investigate the combat effectiveness of American infantryman of World War II. In all, Marshall (1947) interviewed some 400 companies of infantry both in Europe and the South Pacific. His book, Men against Fire, published shortly after the war, is a thoughtful and emotional statement of his findings and opinions.

We remember Marshall's dramatic revelation that in any given engagement only about 20 percent of American infantrymen fire their weapons effectively. But why do men fight? If Marshall has one answer, it is for self-respect.

Perhaps this has been the reason throughout American history. A well-quoted incident from the Civil War hits at the same point. A company of Confederate infantry marching into battle put a rabbit into flight. From the ranks, an anonymous soldier cried, "Go ahead and run, if I didn't have a reputation to live up to I'd run too."

General George S. Patton, in defending the need for the U.S. Military Academy, said "We need the time and kind of training the Point provides to make a man more afraid of his conscience than he is of enemy bullets." (Blumenson, 1972).

World War II Luftwaffe Fighter Commander General Adolph Galland put it this way, ". . .only the spirit of attack born in a brave heart will bring success to any fighter aircraft no matter how highly developed it may be." (Galland, 1954).

While different authors put it in different words - character, self-respect, conscience, the brave heart - their comments are particularly relevant for today's military.[16] Since our military forces must be prepared to fight with fewer, higher cost weapons systems, it becomes increasingly important that we be able to identify those men who will fight and fight effectively.

How does one go about identifying men who will prove themselves in combat? Could anyone have predicted that an uneducated backwoodsman, who resisted induction into the military as a conscientious objector, would become America's most celebrated infantryman of World War I? What characteristics did the poorly educated, rough and tumble, Rickenbacker and the Baron Von Richthofen have in common? Is there a common denominator?[17]

Edward H. Sims, an American World War II fighter pilot turned biographer, in his book, The Greatest Aces (1967) asks this question about the top aces of the RAF, the Luftwaffe, and the USAAF:

> "What about the pilots themselves? What kind of men were they, and are they? How do they vary from country to country and what in them made them stand above the average to become the highest-scoring pilots of their air forces? There is no standard pattern into which one can fit these outstanding fighter pilots. They vary as much, in personality, appearance and behavior, as other individuals though they have a comradeship among themselves. All are alert: one doesn't find the dullard among them -- even years after the war. The significant difference between the top-scoring 'aces' and the average pilot might have manifested itself only in the air -- what they did under various circumstances, how they did it. . .
>
> ". . . of all the top aces of the war he [Hartman] is the greatest enigma. One suspects that somewhere beneath that surface calm, beneath that appearance of fitting into the average-pilot mold, there burns an intense, determined individual, with great self-discipline and an iron will . . ." (p. 5)

Sims, the writer, is expressing an understandable frustration; he holds the conviction that there must be something about the gallant warrior that sets him apart . . . but, for him, it is an elusive factor and not readily apparent.

Pilots, military historians, biographers, and research scientists have all touched upon this issue from their own particular perspective. Our approach to identifying information on what we know about the characteristics of the combat effective is developed in the following subsections (3.2 through 3.6).

3.1.6 Summary - In order to adequately assess air-to-air kill records, the factor of opportunity (i.e., the chance to engage the enemy) needs to be controlled. This factor necessarily affects the number of air kills obtained by an individual pilot. In examining air war kill data for World War I and World War II, it was found that the German and Japanese pilots had a large number of opportunities to engage the enemy, while the British and American pilots had limited opportunities. This is attributable to different management procedures. German and Japanese pilots were kept on constant combat duty, whereas British and American pilots were placed on noncombat tours after a specified period of time or number of combat missions. Similarly,

---

[16]The reader is asked to have some indulgence as we develop our story. The critic may dismiss us prematurely if he demands rigid definition of terms too early on. For example, if we defined character as having a strong sense of "right and wrong," our critic might well dismiss us since he knows of a combat effective veteran who may have once done something "wrong." He establishes very little if he can find exceptions to the general case beyond just that - that he has found an exception (a white crow?).

[17]When we talk about "common denominators" we should be a bit more specific. We are in fact looking for attributes which are commonly (i.e., frequently) shared by a substantial number of combat effective pilots. This is not to say that exceptions to any profile will not come along - they certainly have before - after all, we have seen ace pilots score kills who were missing an eye - Sakai, Japan (Sakai, 1958); an arm - MacLachlan, Britain (Hess, 1968); a leg - Rudel, German (Rudel, 1958); and both legs - Bader, Britain and Maresyev, USSR (Hess, 1968); and there have been female ace fighter pilots - Katia Budanova and Lilya Litvak, both of the USSR (Hess, 1968).

in the Korean and Southeast Asian conflicts, American pilots did not have a large number of engagement opportunities. One solution to this problem is to use a measure suggested by Strawbridge and Kahn (1955), number of kills per opportunity.

In evaluating air war kill data, one of the immediate questions which arises is whether or not reported kill records can be accounted for by chance/luck. Generally, the chance explanation can be rejected. For example, statistical analyses of Air Force kill ratios in Korea and in Southeast Asia revealed that the chance explanation can be ruled out with high levels of certainty. Pilot opinion was in agreement. When pilots were asked if records of air-to-air combat from World War I to the present are due to chance, 71% said they are not.

Finally, one of the most surprising findings resulting from the evaluation of air war kill data is that a small percentage of pilots have been responsible for a large percentage of kills, i.e., approximately five percent have accounted for forty percent of the kills. Due to the low percentage of pilots in this category, it seems that a chance/luck explanation can be discounted with a reasonably high level of certainty. Related to this is the finding that those who survive their first few decisive encounters (five to eight) have a very high probability of surviving succeeding ones. The obvious question is whether this phenomenon is attributable to survival of the fittest, learning (experience), or both. While some have suggested that the observed improvement rate is too extreme to be due to a learning effect (Weiss, 1966), others have argued that the learning explanation cannot be ruled out (Bilikam and Frick, 1970). Additionally, pilot opinion supported the involvement of both survival of the fittest and learning in this phenomenon. It is apparent that controlled research using simulators or air combat maneuvering ranges is required to answer this question.

3.2 SCIENTIFIC STUDIES OF AVIATOR COMBAT EFFECTIVENESS

Research on aircrew performance in combat environments has been very limited and, necessarily, sporadic. That activity which has occurred has not always been well coordinated nor has it been distributed equally among the various services. Figure 3.2-1 lists scientific studies of aircrew performance in times of conflict. The studies are grouped by branch of service and by period of conflict. Inspection of Figure 3.2-1 reveals not only a very limited number of studies in the area, but an inconsistency of effort. Major efforts were launched by both the Army Air Forces and the Navy in World War II, and a substantial research effort was undertaken by the Air Force in Korea. The series of "Red Baron" reports which examined the air war in Southeast Asia, while valuable for other reasons, is limited for our purposes by the overriding issue of opportunity for air kills.

A general finding which emerges from this review is that there is strong precedent for the conduct of pilot selection research in the combat arena. This research was performed surprisingly well in both World War II and Korea considering the short lead time. Unfortunately, with the close of a conflict, interest in developing the selection tools which would be useful in the next conflict wanes, and the continuity of research which should be present is lost.

Because training criteria have been more readily available, military aviation selection research has focused on selection for training success, not success in the operational environment. The problem posed by this research orientation will be discussed below when the criterion issue is addressed.

Although the number of studies of aircrew performance in the combat environment is limited, these studies do allow an assessment of critical skills and individual characteristics which have been related to combat performance. These relationships, both weak and strong, provide the present researchers a fertile source of hypotheses about the makeup of the combat effective aviator. Furthermore, they provide a list of characteristics which with careful evaluation, and properly designed and refined test instruments, could form the basis for a fighter pilot selection program.

3.2.1 Predictor Variable and Criterion Issues

Two interacting basic problems must be dealt with in any personnel selection research program. These problems deal with the selection of predictor variables and with the identification and measurement of criteria. The predictors are likely to be performance measures on tests of various kinds, e.g., motor skills, aptitudes, intelligence, personality, special skills. For fighter pilots, number of air kills should be a good criterion. Other, less satisfactory criteria, such as how well the pilot was liked by his peers, or how well he does in pilot training might also be used.

The index of predictability normally used in selection research is the validity coefficient, which relates performance on some predictor variable to performance on a criterion measure. The higher the validity coefficient (up to a ceiling of 1.0), generally, the better the prediction. If the coefficient falls short of the maximum, it can be because of weakness in the reliability or definition of either predictor or criterion measures. Criticism of the predictor measures is more frequent in the testing literature than criticism of the criterion measures, although both measures are important for prediction. For example, a researcher could show that air superiority fighter pilots who had attended a particular college were universally "liked" by their peers (i.e., have demonstrated a "validity" coefficient of 1.0). While the statistical exercise might be impressive, nothing of practical value exists unless being liked by fellow pilots is a legitimate criterion of combat effectiveness.

This problem of criterion definition is empirically demonstrated in an early 1970's examination of criterion selection in our colleges and

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FIGURE 3.2-1 AVIATION COMBAT STUDIES. THESE ARE DOCUMENTS WHICH REPORT WARTIME AND POSTWAR RESEARCH EFFORTS THAT PERTAIN TO THE COMBAT EFFECTIVENESS OF PILOTS.

universities. (McClelland, 1973). Though polemical in tone, McClelland justifiably points to situations where we have been predicting to success in training, not in the real world. His example, below, makes the point well.

> "I took the top eight students in a class in the late 1940s at Wesleyan University where I was teaching - all straight A students - and contrasted what they were doing in the early 1960s with what eight really poor students were doing - all of whom were getting barely passing averages in college (C- or below). To my great surprise, I could not distinguish the two lists of men 15 - 18 years later. There were lawyers, doctors, research scientists, and college and high school teachers in both groups. The only difference I noted was that those with better grades got into better law or medical schools, but even with this supposed advantage they did not have notably more successful careers as compared with the poorer students who had had to be satisfied with "second-rate" law and medical schools at the outset." (McClelland, 1973, p. 2)

We must be careful in assuming that those who do well in training necessarily will go on to perform well in the operational environment.

In light of the limitations imposed by the real world environment, we must consider carefully the predictors and the criteria used for selecting fighter pilots for the air-to-air role. The remainder of Section 3.2 focuses primarily upon predictor variables. We hope to isolate those characteristics and critical skills which can be used to predict fighter pilot combat effectiveness. This is done at the level of hypothesis generation, and, undoubtedly, the development of specific selection instruments will be required. The criteria cited in this section have been the closest to real world or ultimate criteria of air-to-air combat performance.

3.2.2 Aviation Combat Data - Relating predictor variables to aviation combat success has too often been the goal rather than the activity of many researchers. Nevertheless, our literature search has revealed several studies which quantitatively report the relationships between numerous variables and combat success as interpreted by the particular author. We have chosen to construct a summary of what has been done by analyzing data from various sources and drawing conclusions based upon both the composite and an assessment of insights and conclusions offered by the individual authors. In doing this, we hope to develop a coherent picture of what has gone before.

The reported statistics from the studies are assembled in Figure 3.2-2. Across the top of Figure 3.2-2 are the criteria that have been used by the various researchers. Thirty-nine distinct criteria of combat effectiveness have been used in these studies. Objective criteria of fighter pilot performance range from number of kills and comparisons of aces with nonaces to administrative actions, such as retention in the fighter program. Objective measures of bomber crew performance generally consist of some measure of bombing accuracy. Subjective measures include ratings by psychologists, superiors, and peers. As individual studies are discussed, the various criteria should become clearer. Along the left margin of Figure 3.2-2 are the various characteristics and critical skills which have been used as predictor variables. Most cell entries are correlations between a predictor and a criterion. In some cases, as noted, other statistics such as t, or a critical ratio are included to reflect the relationship between a predictor and a criterion. A slash indicates a range of values. Substantial blank spaces are present in the figure. These spaces serve to emphasize the sporadic and inconsistent nature of the studies dealing with combat effectiveness. They also identify areas for further research, as some seemingly reasonable predictors have only been validated against a single, subjectively based criterion.

Predictor characteristics have been sorted into a tentative taxonomy of characteristics and critical skills making up 11 major selection domains. No preconceived groupings were applied to the data. These categories are meaningful as working hypotheses developed by the present research team, but are not intended to be exhaustive.

STUDY
1 – HEMPHILL & SECHREST (1952)
2 – JENKINS, EWART & CARROLL (1950)
3 – KNOELL (1956)
4 – LEPLEY (1947)
5 – ROFF (1950)
6 – SELLS (1956)
7 – STRAWBRIDGE & KAHN (1955)
8 – TORRANCE, RUSH, KOHN & DOUGHTY (1957)
9 – TRITES & SELLS (1957)

* $p < .05$
** $p < .01$

PREDICTOR	STATISTIC	STUDY	OBJECTIVE CRITERIA: FIGHTERS — ACES VS NONACES χ^2	ACES VS NONACES t	COMBAT KILLS r	COMBAT MISSIONS r	ENEMY SIGHTINGS PER COMBAT MISSION r	ENCOUNTERS PER ENEMY SIGHTING r	ENEMY AIRCRAFT FIRED UPON PER ENCOUNTER r	KILLS PER ENEMY PLANE FIRED UPON r	INDEX A BASED ON KILLS, NUMBER OF ENCOUNTERS, AND OPPORTUNITY r	INDEX B BASED ON KILLS, NUMBER OF ENCOUNTERS, AND NUMBER OF SIGHTINGS r	INDEX C BASED ON KILLS, NUMBER OF ENCOUNTERS, AND NUMBER OF SIGHTINGS r	RETENTION IN FIGHTER PILOT PROGRAM r	RETENTION VS TRANSFER TO OTHER DUTY r	COMBAT FLYING HOURS r	NONCOMBAT FLYING HOURS IN COMBAT ZONE r	RECLASSIFIED VS COMPLETED TOUR CR
APTITUDE																		
PILOT STANINE		4												.14				−.43
		7			.00	.10	−.01	.08	.02	.06	.08		.01					
		8			−.12/.14*													
NAVIGATOR STANINE		4																1.17
		8			−.19*/.17*													
BOMBARDIER STANINE		4																−.65
ENGINEER STANINE		7			.01			.16	−.08	−.09			.53					
OFFICER QUALITY STANINE		8			−.09/.02													
PILOT-PLUS-CREDIT STANINE		7			−.03		.03	.04	−.03	.00	.14		.14					
PERSONNEL TEST		2																
FLIGHT APTITUDE RATING		2																
MECHANICAL INFORMATION		4																−1.30
		8			−.09/.02										.20			
MECHANICAL PRINCIPLES		4																−.18
		7			−.05	.09	−.06	.13	−.11	−.11	−.07		.24					
		8			−.16/−.26*													
MECHANICAL COMPREHENSION		4																
READING COMPREHENSION		4																49
		8			−.23**/−.20													
NUMERICAL OPERATIONS I		8			−.28*/.15													
NUMERICAL OPERATIONS II		8			−.04/.04													
NUMERICAL OPERATIONS-TOTAL SCORE		8			−.31*													
NUMERICAL OPERATIONS		4																1.99
ARITHMETIC REASONING		4																
		8			−.26*/−.16													
MATHEMATICS A		4																1.29
		8			−.13													
MATHEMATICS B		4																1.41
NUMERICAL APPROXIMATION		4																
RATIO ESTIMATION		8			−.01													
GENERAL INFORMATION		4												−.45	−.23			
BIOGRAPHICAL VARIABLES																		
AGE		2																
		5																
		7			.19*	−.09*	.42*	−.18*	−.32*	−.01	−.08	−.08	−.11					
		8			.36**													
EDUCATION		2																
		5																
		8			−.22**													
MILITARY RANK		2																
		8			.37**													
HOURS SINGLE ENGINE TIME		7			.27*	.01	.50*	−.20*	−.23*	.11	−.02		.02					
		8			.32**													
HOURS JET ENGINE TIME		7			.38*	.14*	.41*	.02	−.03	.19*	.38*		.22					
		8			.40**													
TOTAL FLYING HOURS		7			.31*	.01	.53*	−.16*	−.24*	.14	.07		.09					
		8			.41**													
BIOGRAPHICAL DATA-PILOT		4												.02	−.12			
		8			.00/.12													
BIOGRAPHICAL DATA-NAVIGATOR		8			−.07/.05													
BIOGRAPHICAL INVENTORY		2																
BIOGRAPHICAL DATA BLANK		7			.10	−.07	+.20*	−.12	−.18	.22	.10		.19					
FROM LARGE FAMILY	6.82**	8																
ACTIVITY IN FAMILY		7			.03		−.12	.20	.04	.47*	.24							
		8		1.45														
POSITIVE FAMILY AFFECT		7			.10		−.04	.23	.05	.36*	.30							
		8		.59														
LIVED WITH ONLY ONE PARENT	5.06*	8																
FATHER DECEASED	2.31	8																
MOTHER DECEASED	.11	8																
PARENTAL STRIVING		7			.09	−.15	−.06	.28	.21	.27	.46*	.38	.09					
		8		.88														
EARLY PARENTAL CONTROL		7			.03		−.14	.02	.24	.34*	.44							
		8		.30														
EARLY INDEPENDENCE TRAINING		7			.01		.03	.09	.15	.01	.07							
		8		1.64														
TESTING THE LIMITS OF BEHAVIOR		7			.13	−.07	.15	.01	.14	.29	.14	.15	.05					
		8		1.63														
ALWAYS LIVED IN SAME NEIGHBORHOOD	8.53**	8																
MOVED FROM ONE TOWN TO ANOTHER	4.13*	8																
PEER RATINGS IN TRAINING		6																
		9														−.21	.05	
YEARS SINCE PILOT AWARD		8			.32**													
YEAR OF PILOT AWARD		7			−.30*	.02	−.52*	.16	.32*	−.21	.06		.15					
PRIOR FIGHTER COMBAT HOURS		7			.19*	−.10*	.36*	−.16*	−.06	.01	.06		.17					

FIGURE 3.2-2 STATISTICAL RELATIONSHIPS BETWEEN CRITERIA OF COMBAT EFFECTIVENESS AND EXPERIMENTALLY EVALUATED PREDICTORS (ALONG THE LEFTHAND MARGIN). INDIVIDUAL ENTRIES ARE THE STATISTIC INDICATED AT THE TOP OF EACH COLUMN.

			BOMBERS					SUBJECTIVE CRITERIA																			
	NONCOMBAT FLYING HOURS IN COMBAT ZONE r	RECLASSIFIED VS COMPLETED TOUR CR	LEAD PILOTS' AVERAGE ACCURACY r	PERCENT HITS WITHIN 1000 FEET r	RADIAL BOMBING ERROR IN 100'S OF FEET r	CIRCULAR BOMBING ERROR IN 100'S OF FEET r	BOMBING ACCURACY r	SYMPTOMS (PSYCHOLOGISTS' RATINGS IN COMBAT) r	FINAL PSYCHOLOGISTS' RATINGS IN COMBAT UNIT r	G-RATINGS (OVERALL EFFECTIVENESS) r	RATINGS OF FLYING PROFICIENCY r	COMMANDERS' RATINGS OF BEST & POOREST (ALSO XO RATINGS) r	COMPETENCE RATINGS r	FAIRNESS RATINGS r	COURAGE RATINGS r	RESPONSIBILITY RATINGS r	LIKABILITY RATINGS r	DISCIPLINE RATINGS r	MEAN OF RATINGS ON COMPETENCE, FAIRNESS, COURAGE, RESPONSIBILITY, LIKABILITY, & DISCIPLINE r	"ON CREW" CHOICE (PEER NOMINATION TO SHARE DUTY) r	PEER NOMINATION (MOST VS LEAST PREFERRED IN COMBAT) t	ADJUSTED PEER NOMINATION (MOST VS LEAST PREFERRED IN COMBAT) t	BEST VS POOREST BOMBER PILOT KNOWN (DESCRIPTORS) CR	BEST VS POOREST FIGHTER PILOT KNOWN (DESCRIPTORS) CR	SUPERIORS' RATINGS OF COMBAT CREWS r
		-.43	.07/.09	-.06/.04	-.23*/.02	-.06						-.09									.013	.020			
		1.17	.00	-.06/.13	-.05/.01	-.04						-.18									.003	-.012			
		-.65	.08/.10	-.01/-.02	.00/.18*	-.08						-.11													
		-1.30				.23																			
		-.18				.07						-.06													
		.49		.01/.11 -.04/.09	-.07/.11 -.13*/.11	.05/.06 -.06/.13*				-.11 .10		-.02 -.11													
		1.99	.00/.05	-.25*/.07	-.29*/.09	-.02/.10 .00/.15*				.02 .27		-.24*													
		1.29	.00/.04	.02/.14*	-.13*/.09	-.04/.09				.07		-.27*													
		1.41	-.19*/.13*	-.06/-.04	-.20*/.03	.00 .03/.16*				.22		-.08													
											-.30															
																					.040 .046 .021	.194 .164 .274	-.12 -.17	1.53 2.14*	
											.09															
-.21	.05							.10 .38*	43* .40*				.26 .13	.38* .12	.13 .02	.20 .14	.29 .35*	.24 .20	.32* .21		-.043	-.080			

ALLY EVALUATED PREDICTOR VARIABLES (THE CRITICAL SKILLS AND CHARACTERISTICS LISTED
OLUMN.

STUDY
1 – HEMPHILL & SECHREST (1952)
2 – JENKINS, EWART & CARROLL (1950)
3 – KNOELL (1956)
4 – LEPLEY (1947)
5 – ROFF (1950)
6 – SELLS (1956)
7 – STRAWBRIDGE & KAHN (1955)
8 – TORRANCE, RUSH, KOHN & DOUGHTY (1957)
9 – TRITES & SELLS (1957)

* $p < .05$
** $p < .01$

PREDICTOR	STATISTIC	STUDY	OBJECTIVE CRITERIA: FIGHTERS — ACES VS NONACES x^2	ACES VS NONACES t	COMBAT KILLS r	COMBAT MISSIONS r	ENEMY SIGHTINGS PER COMBAT MISSION r	ENCOUNTERS PER ENEMY SIGHTING r	ENEMY AIRCRAFT FIRED UPON PER ENCOUNTER r	KILLS PER ENEMY PLANE FIRED UPON r	INDEX A BASED ON KILLS, NUMBER OF ENCOUNTERS, AND OPPORTUNITY r	INDEX B BASED ON KILLS, NUMBER OF ENCOUNTERS, AND NUMBER OF SIGHTINGS r	INDEX C BASED ON KILLS, NUMBER OF ENCOUNTERS, AND NUMBER OF SIGHTINGS r	RETENTION IN FIGHTER PILOT PROGRAM r	RETENTION VS TRANSFER TO OTHER DUTY r	COMBAT FLYING HOURS r	NONCOMBAT FLYING HOURS IN COMBAT ZONE r	RECLASSIFIED VS COMPLETED TOUR CR	LEAD PILOTS' AVERAGE ACCURACY r
SOCIAL FACTORS																			
WORKING WITH SUPERIORS		1																	
WORKING WITH OTHER CREWS		1																	
SOCIAL PARTICIPATION		7			.01	–.07	–.05	.02	.18	.08	.16	.20	.25						
LIKING FOR OWN CREW		3																	
PERSONALITY																			
CONSIDERATION		1																	
CONSIDERATION FOR MENS' COMFORT & INTERESTS		5																	
PERSONAL ACCEPTABILITY		5																	
SINCERITY		5																	
ACCEPTANCE OF RESPONSIBILITY		5																	
IMPARTIALITY		5																	
EVENNESS OF TEMPER		5																	
MODESTY		5																	
COURAGE		5																	
ENTHUSIASTIC ABOUT COMPETITION		8	8.06**																
CONFLICT		7			.14		.12	–.01	.12	.12	–.07								
		8		.78															
MADE SPECIAL ATTEMPT TO FLY FIGHTER PLANES		8	18.26**																
ENTHUSIASM		5																	
PHYSICAL AGGRESSIVENESS		7			.26*	–.20	.25*	–.10	.01	.36*	.01	.06	–.09						
		8		.81															
VERY AGGRESSIVE CHILDHOOD BEHAVIOR (FIGHTING)		8	24.3**																
NEUROTIC CHILDHOOD TRAITS		7			–.14	.03	–.02	–.00	–.24	–.05	–.38	–.34	–.24						
		8		–2.65*															
FISHERS RIGIDITY INDEX (RORSHACH)		8		2.71**															
BECK'S ORGANIZATIONAL Z (RORSHACH)		8		2.09*															
TOTAL RESPONSES (RORSHACH)		8		2.09*															
TOTAL MOVEMENT (RORSHACH)		8		1.96															
PERSONALITY (LEADERSHIP)																			
APPROACHIBILITY		5																	
ABILITY TO DELEGATE RESPONSIBILITY		5																	
ABILITY TO MIX WITH SUBORDINATES		5																	
KNOWLEDGE OF ABILITIES & LIMITATIONS OF EACH MAN		5																	
EFFECTIVE USE OF PRAISE & BLAME		5																	
STRICTNESS OF GROUND DISCIPLINE		5																	
ADEQUACY OF GROUND DISCIPLINE		5																	
MAINTENANCE OF AIR DISCIPLINE		5																	
SHARING OF WORK & HARDSHIPS ON THE GROUND		5																	
RESPONSIBLE FOR HIS MEN IN COMBAT		5																	
WILLINGNESS TO PASS ON INFORMATION TO SUBORDINATES		5																	
DECISIVENESS IN ADMINISTRATION		5																	
ABILITY TO CUT RED TAPE TO GET THINGS DONE		5																	
CONCERN WITH PERSONAL ADVANTAGE		5																	
ADJUSTIVE SKILLS		7			.07		.20	–.12	–.02	.09	–.37								
REACTION TO STRESS																			
SHARING OF DANGERS		5																	
NO EMOTIONAL REACTION TO COMBAT ENCOUNTER		8	6.75**																
PLANNING FOR COMBAT SITUATIONS		5																	
AIMING STRESS		4												.03	.08			1.26	
MOTIVATION (ATTITUDES)																			
WORKING HARD – NOT HAVING TIME ON HANDS		8	3.82**																
CONSISTENCY OF EFFORT		5																	
INTEREST IN NON-FLYING DUTIES		5																	
DESIRED SECOND COMBAT TOUR		8	21.88**																
CONSCIENTIOUS ABOUT TRAINING & PERFORMANCE OF HIS OUTFIT		5																	
SENSE OF PERSONAL WELL-BEING IN THE AIR FORCE		3																	
CONFIDENCE IN SUPERIOR OFFICERS		3																	
SENSE OF SAFETY IN FLYING		3																	
SATISFACTION WITH JOB ASSIGNMENT		3																	
ACCEPTANCE OF AIR FORCE GOALS		3																	
IMPORTANCE OF THE KOREAN WAR		3																	

FIGURE 3.2-2 STATISTICAL RELATIONSHIPS BETWEEN CRITERIA OF COMBAT EFFECTIVENESS AND EXPERIMENTALLY EVALUATED P
ALONG THE LEFTHAND MARGIN). INDIVIDUAL ENTRIES ARE THE STATISTIC INDICATED AT THE TOP OF EACH COLUMN. (Continued)

			BOMBERS					SUBJECTIVE CRITERIA																		
COMBAT FLYING HOURS	NONCOMBAT FLYING HOURS IN COMBAT ZONE	RECLASSIFIED VS COMPLETED TOUR (CR)	LEAD PILOTS' AVERAGE ACCURACY	PERCENT HITS WITHIN 1000 FEET	RADAL BOMBING ERROR IN 100'S OF FEET	CIRCULAR BOMBING ERROR IN 100'S OF FEET	BOMBING ACCURACY	SYMPTOMS (PSYCHOLOGISTS' RATINGS IN COMBAT)	FINAL PSYCHOLOGISTS' RATINGS IN COMBAT UNIT	G-RATINGS (OVERALL EFFECTIVENESS)	RATINGS OF FLYING PROFICIENCY	COMMANDERS' RATINGS OF BEST & POOREST (ALSO XO RATINGS)	COMPETENCE RATINGS	FAIRNESS RATINGS	COURAGE RATINGS	RESPONSIBILITY RATINGS	LIKABILITY RATINGS	DISCIPLINE RATINGS	MEAN OF RATINGS ON COMPETENCE, FAIRNESS, COURAGE, RESPONSIBILITY, LIKABILITY, & DISCIPLINE	"ON CREW" CHOICE (PEER NOMINATION TO SHARE DUTY)	PEER NOMINATION (MOST VS LEAST PREFERRED IN COMBAT)	ADJUSTED PEER NOMINATION (MOST VS LEAST PREFERRED IN COMBAT)	BEST VS POOREST BOMBER PILOT KNOWN (DESCRIPTORS) (CR)	BEST VS POOREST FIGHTER PILOT KNOWN (DESCRIPTORS) (CR)	SUPERIORS' RATINGS OF COMBAT CREWS
							57* 47*													.11 .06					.34*
							42*													.10			19.29* 30.17* 27.00* 23.72* 24.04* 14.85* 20.44* 24.74* 17.29*	13.51* 17.02* 15.89* 22.22* 17.96* 11.19* 10.75* 16.52* 13.39*	
																							21.22* 19.33* 21.04* 23.40* 24.55* 29.94* 13.79* 23.09* 19.43* 25.82* 19.28* 18.20* 15.71* 24.27*	12.20* 13.50* 15.78* 15.58* 16.13* 26.35* 12.92* 13.43* 13.45* 16.41* 12.03* 13.33* 15.46* 20.07*	
		1.26									.08												18.68* 18.31*	14.12* 12.49*	
																							24.06* 8.97* '8.85	18.17* 5.33* 12.88*	17 29* 28* 24* 41* 14

TALLY EVALUATED PREDICTOR VARIABLES (THE CRITICAL SKILLS AND CHARACTERISTICS LISTED
COLUMN. (Continued)

STUDY
1 – HEMPHILL & SECHREST (1952)
2 – JENKINS, EWART & CARROLL (1950)
3 – KNOELL (1956)
4 – LEPLEY (1947)
5 – ROFF (1950)
6 – SELLS (1956)
7 – STRAWBRIDGE & KAHN (1955)
8 – TORRANCE, RUSH, KOHN & DOUGHTY (1957)
9 – TRITES & SELLS (1957)

* $p < .05$
** $p < .01$

PREDICTOR	STUDY	OBJECTIVE CRITERIA: FIGHTERS — ACES VS NONACES χ^2	ACES VS NONACES t	COMBAT KILLS r	COMBAT MISSIONS r	ENEMY SIGHTINGS PER COMBAT MISSION r	ENCOUNTERS PER ENEMY SIGHTING r	ENEMY AIRCRAFT FIRED UPON PER ENCOUNTER r	KILLS PER ENEMY PLANE FIRED UPON r	INDEX A BASED ON KILLS, NUMBER OF ENCOUNTERS, AND OPPORTUNITY r	INDEX B BASED ON KILLS, NUMBER OF ENCOUNTERS, AND NUMBER OF SIGHTINGS r	INDEX C BASED ON KILLS, NUMBER OF ENCOUNTERS, AND NUMBER OF SIGHTINGS r	RETENTION IN FIGHTER PILOT PROGRAM r	RETENTION VS TRANSFER TO OTHER DUTY r	COMBAT FLYING HOURS r	NONCOMBAT FLYING HOURS IN COMBAT ZONE r	RECLASSIFIED VS COMPLETED TOUR CR
AVIATOR SKILLS, KNOWLEDGES, TASKS																	
TECHNICAL SKILLS	1																
KNOWLEDGE OF COMBAT FLYING	5																
PROFICIENCY IN HIS RATED SPECIALTY & KNOWLEDGE OF HIS EQUIPMENT	5																
KNOWLEDGE OF JOBS OTHER THAN OWN SPECIALTY	5																
FLYING JUDGMENT	5																
AIR FORCE VOCABULARY	4																
TECHNICAL VOCABULARY – PILOT	4													.00	1.0		
	7			.08	.08	.07	.13	.01	–.01	–.24		–.02					–1.85
	8			–.13/.07													
TECHNICAL VOCABULARY – NAVIGATOR	4																–.22
	8			–.18													
TECHNICAL VOCABULARY – BOMBARDIER	4																–.22
INSTRUMENT COMPREHENSION	8			–.29*/.17													
COORDINATE READING	8			.10													
ELECTRICAL INFORMATION	8			.02													
RATIO ESTIMATION	8			–.01													
DIAL & TABLE READING	4																1.16
	8			–.17/.13													
DIAL READING	4																
TABLE READING	4																
MILITARY BEARING																	
CARE OF AIRCRAFT	1																
FOLLOWING SOP	1																
MILITARY BEARING	1																
OFFICER QUALITY	7									–.06		–.19					
	8			–.09/–.02													
DECISION MAKING																	
QUALITY AND SPEED OF COMBAT DECISIONS	5																
JUDGMENT	8			.03													
	7			.01	.10	.04	.21	–.33	–.08	–.09		–.03					
RISK & STRATEGY	8		3.07**														
	7			.38*	–.15	.45*	–.04	.05	.11	–.08	–.10	–.37					
READING & JUDGMENT	4																
SENSORY – MOTOR ABILITIES																	
PATTERN ORIENTATION	8			.14													
FINGER DEXTERITY	4													.09	.12		
	7							–.14	.01								–.88
	8			.02/.13													
RUDDER CONTROL	7			.03	.10	.04	–.04	–.06	–.03	–.14		.02					
	8			.18*													
STEADINESS	4																
COMPLEX COORDINATION	4													.10	.20		
	7			–.05	.04	.00	.05	–.17	.02	.03		–.15					–.46
	8			–.03/.12													
DISCRIMINATION REACTION TIME	4													.11	.11		
	7								.03	–.03							.63
	8			.01/.02													
TWO HAND COORDINATION	4													–.05	.12		
	7							.06	.04								.06
	8			–.05/.04													
SPEED OF IDENTIFICATION	4													.04	–.04		.05
ROTARY PURSUIT	4													.22	.08		
	7						.04	–.01	.05								–1.94
	8			.14/.18**													
SPATIAL ORIENTATION I	4													.18	.08		
	7						–.02	.18	–.08								.34
	8			.08/.12													
SPATIAL ORIENTATION II	4													.07			
	7						.07	.07	.01								.82
SPATIAL ORIENTATION III	8			.05/.08													
	4																

FIGURE 3.2-2 STATISTICAL RELATIONSHIPS BETWEEN CRITERIA OF COMBAT EFFECTIVENESS AND EXPERIMENTALLY EVALUATED ALONG THE LEFTHAND MARGIN). INDIVIDUAL ENTRIES ARE THE STATISTIC INDICATED AT THE TOP OF EACH COLUMN. (Continued)

				BOMBERS					SUBJECTIVE CRITERIA																				
r	COMBAT FLYING HOURS r	NONCOMBAT FLYING HOURS IN COMBAT ZONE r	RECLASSIFIED VS COMPLETED TOUR CR	LEAD PILOTS' AVERAGE ACCURACY r	PERCENT HITS WITHIN 1000 FEET r	RADIAL BOMBING ERROR IN 100's OF FEET r	CIRCULAR BOMBING ERROR IN 100'S OF FEET r	BOMBING ACCURACY r	SYMPTOMS (PSYCHOLOGISTS' RATINGS IN COMBAT) r	FINAL PSYCHOLOGISTS' RATINGS IN COMBAT UNIT r	G-RATINGS (OVERALL EFFECTIVENESS) r	RATINGS OF FLYING PROFICIENCY r	COMMANDERS' RATINGS OF BEST & POOREST (ALSO XO RATINGS) r	COMPETENCE RATINGS r	FAIRNESS RATINGS r	COURAGE RATINGS r	RESPONSIBILITY RATINGS r	LIKABILITY RATINGS r	DISCIPLINE RATINGS r	MEAN OF RATINGS ON COMPETENCE, FAIRNESS, COURAGE, RESPONSIBILITY, LIKABILITY, & DISCIPLINE r	"ON CREW" CHOICE (PEER NOMINATION TO SHARE DUTY) r	PEER NOMINATION (MOST VS LEAST PREFERRED IN COMBAT) r	ADJUSTED PEER NOMINATION (MOST VS LEAST PREFERRED IN COMBAT) r	BEST VS POOREST BOMBER PILOT KNOWN (DESCRIPTORS) CR	BEST VS POOREST FIGHTER PILOT KNOWN (DESCRIPTORS) CR	SUPERIORS' RATINGS OF COMBAT CREWS r
								61*														20				21.90* 24.83* 19.18* 26.60*	15.06* 16.45 13.56* 17.07*	
			-1.85	.05	.06	-.10/.09	-.22* .03/.11				-.02	.03	-.08															
			-.22	-.17*/-.12	.02/.03	-.06/.01	-.08/.05				.09		.00															
			-.22	-.12/.00	.13*/.15*	-.06/.20*	-.181*/.05				.05		-.05															
			1.16	.11/.14*	-.16*/-.13*	-.30*/-.09	-.04 .03/.06 .06/.09				.23 .12		.07															
								.38* .40* .27*														.26* .15 .25*						
							-.02/-.01				-.05															27.51*	21.66**	
			-.88	.11/.13*	-.04/.04	-.06/.15*	-.09/.12				.11	.04	.07															
			-.46	.24*/.25*	-.03/.13*	-.06/-.05	.07/.21 -.06/.23*				.14 .16	-.01	.05															
			.63	.01/.36*	-.03/.20*	-.11/.26*	-.05/.12				.24*	.11	-.03															
			.06	.08/.27*			-.26*/.01					-.10	-.39*															
			.05	-.08/.00	.00/.12	.05/.20*	-.05/.12				.05	-.08	.04															
			-1.94				-.02					.07	.01															
			.34				-.12				.00	.13																
			.82				.14*				.00	.05																
							-.18*																					

ENTALLY EVALUATED PREDICTOR VARIABLES (THE CRITICAL SKILLS AND CHARACTERISTICS LISTED
CH COLUMN. (Continued)

3.2.2.1 World War II Studies - Before World War II the selection of pilots was based upon age, education, and a thorough medical examination (DuBois, 1947). The number of pilots flowing through the pre-war military system (the total force strength was under 1000 officers) allowed that limited selection approach to be adequate. However, the requirement in World War II to fill more cockpits and fill them quickly demanded improved procedures for pilot selection. With the demand for improved selection and training of pilots, the Army Air Forces (AAF) Aviation Psychology Program was established in June of 1941. That program dealt primarily with aircrew selection and training, but also examined personnel problems in other AAF settings. From the Aviation Psychology Program work a 19 volume document emerged reporting all phases of that research program.[1] The portion of the work predicting training success is described in Section 3.4 of the present report.

In addition to predicting success in training, the Army Air Forces Aviation Psychology Program was specifically tasked with discovering, " . . . the extent to which known individual differences in aptitudes and other traits are reflected in the combat effectiveness of air-crew personnel," (Lepley, 1947, p. 12). Forced to gear up rapidly, the research team started with tests which were developed for predicting training success and collected data on four types of criteria. They were objective measures, administrative actions, direct and systematic observations, and ratings based on general impressions. (The fourth category includes the criterion used by the Naval Aviation researchers.) The four classes of criteria were selected according to availability and apparent correspondence with the ultimate criterion, objectively demonstrated combat effectiveness. The objective measures, in some instances, are the ultimate criterion (as in enemy kills), but even these measures were subject to some problems since the quality of records was degraded because of the exigencies of the combat environment. The other criterion measures, even as intermediate criteria, (see Throndike, 1947, 1949) were collected in the theater of operations, and, as such, should reflect a better approximation of the ultimate criterion. Despite the problems encountered in this work, this research program far exceeded, in scope, data collection, and analysis, other pilot selection research efforts which were conducted during World War II.

The criterion measures for the Lepley (1947) studies were retention in the fighter program, completing a tour versus being reclassified, commanders' ratings of best and poorest pilots, G-ratings[2], and objective measures of bombing accuracy. This is a broader range of combat criteria than other researchers have used. Similarly, the Air Force researchers in World War II evaluated a very broad range of predictors. Lepley reports some disappointment in the magnitude of the validity coefficients obtained. In historical perspective, however, the results of that combat validation program are profound, both in terms of the groundwork laid for later personnel research and in terms of some specific findings. Certain of the validity coefficients were impressive. For example, discrimination reaction time correlated significantly with G-ratings and three measures of bombing accuracy (see Figure 3.2-2).

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[1]It began when Col. (Dr.) John C. Flanagan reported for duty in July of 1941. Dr. Flanagan had, as a civilian, been the Associate Director of the New York based Cooperative Test Service (DuBois, 1947). Immediately, he drew together a highly talented group of experimental psychologists and established what probably was the most effective applied psychological research team ever. Most went on to achieve unusually high levels of prominence in psychology. Col. Flanagan's team leaders were: Sidney W. Bijou, Clarence W. Brown, Launor F. Carter, Stuart W. Cook, Meredith P. Crawford, John T. Dailey, Frederick B. Davis Walter L. Deemer, Philip H. DuBois, Paul M. Fitts, Edwin E. Ghiselli, James J. Gibson, J. P. Guilford, R. N. Hobbs, A. Pemberton Johnson, Edward H. Kemp, John I. Lacy, William M. Lepley, Arthur W. Melton, Neal E. Miller, Richard T. Solenberger, Robert L. Thorndike, Louis B. Ward, and Frederic Wickert. Three other major figures in the total effort were Frank Geldard of Hq. Training Command, Lawrence Shaffer of Hq. Redistribution Command, and Paul Horst, an expert in statistics and test theory.

[2]G-ratings involve an overall assessment of pilot proficiency.

The combat validation activities of several AAF projects during World War II are reported in one of the 19 volumes reporting the work of the entire Aviation Psychology Program under the direction of Dr. Flanagan.[3] The research team collected data for combat validation on the performance of navigators, bomber pilots, and fighter pilots from the Seventh, Eighth, Ninth, Tenth, Twelfth, and Fifteenth Air Forces.

Two technical problems which plagued the group were restricted ranges of the predictor measures and variation in opportunity of pilots to engage the enemy (Lepley, 1947). The former was due to a cascaded selection process which eliminated unsuitable combatants at several steps prior to their entrance into the operational environment. That is, a great deal of inter-individual variability, which probably existed in several measures of the population of potential pilots, had been reduced. The opportunity problem is a factor which can be partially controlled by matching the pilots by number of missions or critical missions, but has been a pervasive problem in attempts at combat validation (see Section 3.1).

In addition to the large scale bomber pilot, navigator, and bombardier combat validation studies, a special study of 152 fighter pilots from the 413th Fighter Group was conducted. This study was designed to ask if combat proficiency can be predicted from observations made in the Zone of the Interior. Special rating procedures were developed for this study. Pilots were rated on alertness, personality, eagerness for combat, dependability, air discipline and teamwork, conscientiousness, flying proficiency, and overall compatability. Ratings of pilots at the end of four months of training were compared with ratings of the combat proficiency made by flight leaders after 9 to 16 combat missions in the Pacific. The product-moment correlations between those two ratings yielded a correlation coefficient of 0.62 (Lepley, 1947, p. 187). That clearly shows better than chance prediction of combat effectiveness. This is one of the few cases where the combat performance of fighter pilots has been predicted. In most of the studies yielding data which are included in Figure 3.2-2, the researchers collected data and then looked back to see how well they could have predicted the combat criterion. Though the pilots of the 413th Fighter Group were flying P-47s, a plane substantially different from current air superiority fighter planes, testing and selection techniques which worked in that situation should still be applicable since substantial overlaps of critical aviator skills exist.

Though Dr. Flanagan's group executed the most thorough research program on AAF personnel, some other studies were performed which merit discussion. Roff (1950) for example, administered a rating scale of characteristics related to effectiveness in combat leadership to returned flying officers. His goal was to determine the relative importance of different types of behavior in the command situation. "Strictness of Ground Discipline" emerged as the major factor in this study of 306 officers rated as poor. Unfortunately, a bias existed in this study because of the after-the-fact assessment of the characteristics of the best and poorest officers. Because of this, the statistical significances associated with the statistics reported from the Roff study in Figure 3.2-2 may be artificially high. Nevertheless, some meaning can be attached to the relative value of the various characteristics identified as descriptors of the combat effective.

Like the Army Air Forces, the Navy had a coordinated research program on pilot selection during World War II. Though less extensive than the AAF program, certain similarities in problems and approaches existed. The Navy program was under the direction of Capt. (Dr.) John G. Jenkins. As with the AAF researchers, the Navy researchers performed an extensive job analysis and search for valid

[3]The Lepley volume is No. 17 in that set.

criteria. As Jenkins, et al, (1950) put it, "It was early recognized, . . . that degree of proficiency exhibited during flight training, above the requisite level for completing training satisfactorily, might not be correlated highly with effectiveness in combat." This is a point which cannot be overemphasized. Not only are many of the tasks of combat aviation more demanding than training tasks but the stress of actual combat is present.

In response to the recognition, within the Navy hierarchy, of the importance of developing a criterion of success in combat, in September of 1943, three officers were charged with identifying potentially valid "combat" criteria. After compiling a file of 1818 cases of pilots judged good or poor, the three investigators delineated several reasonable criteria. These included ratings by peers, ratings by squadron commanders, ratings by instructors, success in field carrier landing practice, torpedo tactics practice, and training records. Other members of the Navy research team took the list of criteria, and after carefully evaluating scientific, administrative, and data collection restrictions, the Navy combat criterion for the major World War II research effort was established. It consisted of "high" versus "low" combat nominations by peers. That is, Naval aviators with combat experience named men on whom they would be glad to fly wing, "highs," and men they would not want flying wing on them, "lows." Referring to the development of the Navy combat criterion, Fiske (1947) noted that number of planes shot down, decorations, and other proficiency measures were found inadequate in preliminary research. This undoubtedly influenced the choice of combat nominations as the combat criterion to be used in World War II Navy pilot selection research. An implicit assumption of the combat nomination technique is that peers of the combat aviator are good judges of his effectiveness. This, of course, is one manifestation of the criterion problem which is critical to proper validation of all selection devices. There is no way to be sure that peer nominations are adequate as a criterion.

The exigencies of war precluded active adherence to certain practices regarding selection and training. In assessing the Naval aviation program of World War II, Captain Jenkins and his staff were painfully aware that success in training, although a necessary prerequisite for combat success was not adequate as a criterion for the selection of aviators. They noted (Jenkins, et al 1950, p. 168),

> "These analyses involving test score data render one point unequivocal. The test battery which functioned to predict success in training does not predict this combat criterion."

Fiske (1947, p.73) describing the Navy program noted that,

> "Although the need for validating the selection tests against combat criteria was repeatedly stated in official memoranda, wartime expediency prevented the establishment of this ultimate check during the early years of the war."

Discussing the lessons learned by psychologists during World War II, Fiske (1947, p. 72) noted,

> "Psychologists have been so much preoccupied with the immediate task of constructing reliable measuring devices that they have often slighted the criterion itself. It was the experience of the aviation group that constructive efforts to improve the reliability and the significance of criterion measures deserve at least as much attention as that given to the predictor itself."

As can be plainly observed in the column labeled Peer Nomination in Table 3.1-2, the correlations between the predictors used and the Navy combat criterion were very low except for the predictor, military rank, which is a confounded factor if one accepts the premise that the effective aviator is more likely to be promoted. A note of caution must be exercised in assessing these correlation coefficients, and that is that the predictor variables used by Jenkins, et al, (1950) were developed primarily to predict training success, not combat success. That research team did note, however, that promise was indicated for the development of a combat key for scoring the Biographical Inventory, a specially devised life history questionnaire. Jenkins' untimely death substantially dampened the Navy selection research efforts and delayed the reporting of the results of the World War II

activities for several years. Unfortunately, major strides in the direction of a more refined key or better biographical inventory were not made by other Naval researchers.

The major Navy combat validation effort was continued until the end of World War II. Data on 4325 Navy pilots were obtained from 2872 men stationed in the Pacific. Jenkins, et al, (1950) performed a factor analysis on that data to identify characteristics of the "high" group. Eight characteristics were tentatively identified. They were (1) leadership and responsibility, (2) teamwork, (3) practical intelligence, (4) combat aggressiveness, (5) skill and interest in flying, (6) seriousness, conscientiousness, (7) coolness, steadiness, and (8) easy-going sociability. The order of the listing of the factors above reflects the rank ordering assigned by a group of pilots when queried by the Jenkins research team. Recognizing that their peer nomination combat criterion was imperfect, Jenkins, et al, (1950) hoped to use these initial findings for the development of a more sophisticated peer rating instrument.

Viewing the problem at a more general level, Jenkins, et al, (1950) noted that they were essentially looking at only one criterion. They also noted that an overlap between combat and operational criteria measures must exist. Jenkins, et al, 1950, p. 260) at the conclusion of World War II were saying,

> "Validation of selection instruments could be made in terms of measures of those areas of operational success which were considered common to combat effectiveness. Moreover, artificial situations might be devised, by means of which potential effectiveness in areas of the combat criterion, not routinely sampled in the operational situation, could be evaluated."

They made a strong call for additional research aimed at the development of tests predictive of behavior associated with the areas of combat performance.

John T. Bair (1952) obtained statements from more than 1000 World War II combat tested Navy pilots in an attempt to compare the attitudes of men in training with those of men in combat. Students were asked to describe an incident which typified the best and worst cadets they had known. The combat criterion used in the Bair study, like that in the Jenkins, et al, (1950) work, consisted of naming individuals he would not want to fly with. Bair did not report quantitative data, but he did specify these characteristics of the pilot wanted in combat from his assessment of the data:

- Teamwork and Consideration for Others
- Desire to Fly and Skill in Flying
- Personal Stability and Calmness
- Social Adaptability and Easy Going Temperament
- Conscientiousness and Ability to Accept Responsibility.

Bair felt that the best cadets and men wanted in combat compared favorably. He made only qualitative comparisons since frequencies of response were not available.

Using the Navy combat criterion, Trumbull and Backstron (1946) found a relationship between job preference and success. More of those pilots who had shown a strong preference to be fliers were successful than those who wanted ground duty, and, similarly, assignment to a preferred type of plane (e.g., fighters as opposed to bombers) appeared to be related to combat success. This lends additional credence to the "Desire to Fly" characteristic cited by Jenkins et al, (1950).

A shift away from selection occurred in the Navy research community late in World War II. This was primarily a result of other demands on the psychologists' time . . . "Undoubtedly, this shift of emphasis resulted in some neglect of the selection program in which there was always considerable room for improvement." (Fiske, 1947, p. 71).

Other types of pilot research were also being conducted in the theaters of war. For example, a Special Service Division memo in July 1944 reported a comparison of attitudes toward combat flying held

by fighter and bomber pilots. Fighter pilots were more willing to undertake an additional series of combat missions than their bomber pilot counterparts.

The Civil Aeronautics Administration (CAA) in 1939 joined with the National Research Council (NRC) and created what became the CAA-NRC Committee on Selection and Training of Aircraft Pilots (Viteles, 1945). The developments made by that group in the selection and training of civilian pilots greatly influenced the military selection research and when World War II started, leading aviation psychologists from both the Army Air Forces and the Navy joined forces with the CAA-NRC group. The Committee included prominent psychologists, physicians, physiologists, engineers, pilots, and military men. Membership, in addition to the chairman, Morris S. Viteles, included John C. Flanagan and J. G. Jenkins. In summarizing the practical outcomes of the work on pilot selection and classification, Viteles (1945) listed the following four items:

- The validation of a number of predictors for use in both military and civilian aviation
- The accumulation of data on predictors which, although not fully validated, represent promising instruments for further research and application
- The identification of tests and other techniques which, while having apparent face validity or originally recommended for other reasons, proved, upon investigation, to lack reliability or validity
- The identification of predictors which, although valid, represent uneconomical techniques for the selection and classification of pilots.

In addition, the CAA-NRC Committee on Selection and Training of Aircraft Pilots provided a forum for the exchange of information on pilot selection and stimulated nationwide interest in aviation psychology.

3.2.2.2 Korean War Studies - Interest in fighter pilot combat effectiveness was renewed during and immediately after the Korean conflict. Noting that of the 800 F-86 pilots who had been on 25 or more counterair missions, less than 10% scored over 50% of the kills, the Far East Air Forces requested an assessment of what makes an ace. HQS USAF responded and a team of scientists under the direction of Dr. E. Paul Torrance set out to find some answers. Torrance (1954) developed a 100 item preliminary life experience inventory. This questionnaire, accompanied by interviews, Rorschach tests, and an ability questionnaire, was used to assess over 700 fighter pilots evaluated in a study by Torrance, Rush, Kohn and Doughty (1957). Torrance, et al, (1957) used the number of kills as a basic criterion measure. Direct comparisons of 27 aces and 27 nonaces were also made by this group. As shown in Table 3.2-2, age, rank, time service, and flying time were found to be significantly related to kill claims. The selection devices which had been validated on success in training (e.g., stanines) were not shown to correlate with the number of kills.

In the comparison of aces and nonaces, Torrance, et al, (1957) indicated that the following five factors differentiated between these groups. Aces tended to (1) exhibit fewer childhood neurotic behaviors, (2) achieve better social adjustment, (3) participate in a larger number of every day activities involving risk and strategy, (4) test the limits of behavior as boys, and (5) receive more early independence training. The interview data indicated that aces exhibited greater motivation. This was evidenced by more special attempts on the part of aces to become fighter pilots and overt efforts to obtain additional combat duty.

The Torrance Life Experience Inventory and a large set of other measures were used by Strawbridge and Kahn (1955) in an intensive study of Korean pilots. There was some subject overlap as 73 of the subjects participating in that study had also been evaluated in the Torrance, et al, (1957) study. Strawbridge and Kahn questioned the validity of the raw number of kills as the primary measure of combat effectiveness. They argued that opportunity and other artifactual factors were involved in getting kills and, because of this, some better measures of fighter pilot combat effectiveness were possible. Strawbridge and Kahn (1955) suggested some alternatives and used as their criteria these nine variables: M, K, S/M, E/S, F/E, K/F, A, B, C
where:

M is the number of combat missions flown by a pilot while on duty with the Fourth Fighter Interceptor or Wing in Korea.

S is the number of occasions when enemy aircraft formations were sighted by a friendly flight on combat patrol while the pilot was serving as a leader in the flight. Leader as used here is defined to mean a pilot flying No. 1 position in a flight or element, a pilot flying No. 3 position when flying as an element, any pilot when firing on the enemy, and any pilot when flying alone.

E is the number of encounters with enemy aircraft when on combat patrol as leader. An encounter is here defined to mean any attempt of a pilot to close on the enemy following a sighting or the initiation of an attack by the enemy.

F is the number of enemy aircraft fired upon by a pilot when serving as leader.

K is the number of enemy aircraft destroyed by a pilot. This is a weighted kill measure in which a destruction is assigned a value of 1.00, a probable destruction 0.75 and a damage of 0.25. Shared credits between two or more pilots are scored accordingly.

Index A is an adjusted ratio of kills per opportunity. Index B is based upon M, S, E, F, and K. Index C is similar to B but with an adjustment for opportunity associated with position in the formation.

Clearly, mission differences and even position in formation differences (lead versus wing) can influence the number of kills. As noted by Strawbridge and Kahn (1955), a pilot who flew a disproportionately large number of reconnaissance, intercept, air rescue, or escort missions had less opportunity to encounter the enemy.[4] Another legitimate and related problem with number of kills as the primary criterion measure has to do with its sensitivity. As an all or none measure, which occurs relatively infrequently, kills might bypass some excellent pilots. Kills might legitimately be augmented with some additional measures of pilot performance, but the face validity and apparent utility of such a measure is so overwhelming that any dismissal of it as major criterion of air-to-air combat effectiveness is unthinkable.

Strawbridge and Kahn (1955) correlated some of the 42 predictors (shown in Figure 3.2-2) with their criterion variables. In Figure 3.2-2 one can see that those predictors covered a wide range of pilot skills and characteristics. Experience factors, (e.g., flying hours), aggressiveness, risk taking, and general information yielded the highest correlations with the kills measure. Most highly correlated with the Strawbridge and Kahn indices of combat effectiveness were flying experience and the life history factors of parental control and the parental striving. The Strawbridge and Kahn study appears to be one of the best conceived studies of combat effectiveness encountered by the present research team.

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[4]For a discussion of opportunity see Section 3.1.

The call for research from the Far Eastern Air Forces also led to the study of combat crew attitudes (Degaugh and Knoell, 1954; Knoell and Stice, 1954; Knoell, French and Stice, 1953). In a sample of forty-two Korean War B-29 crews which flew bombing and propaganda missions over North Korea, Knoell (1956) was able to show significant relationships between attitudes measured in training and combat performance as reflected in ratings of crew performance made by superior officers. The three attitude scales which, for Knoell, predicted combat performance best were sense of personal well-being in the Air Force, acceptance of Air Force goals, and liking for ones own crew. The sample in the Knoell Study was not limited to pilots but involved the entire aircrew, i.e., aircraft commander, pilot, navigator, radar observer, bombardier, flight engineer, radio operator, and four gunners. Knoell found that two conclusions were supported, ". . . namely, that crew attitudes measured in training predict rated crew combat performance significantly, and that crew attitude measures in combat are correlated significantly with the crews' rated combat performance." (Knoell, 1956, p. 15).

With full awareness that Air Force tests were being validated on training success, not on performance in the operational environment, Tupes surveyed and developed some officer effectiveness measures (Tupes, 1957). For that more general purpose, five types of predictors were thought appropriate. They were (1) peer and superior ratings of leadership potential, (2) peer ratings on personality traits, (3) a biographical-interest-personality inventory, (4) a physical proficiency test, and (5) a situational performance test series. Tupes, Carp, and Borg (1957) validated the battery on four intermediate criteria. Three of the four criterion variables were, however, training based (OCS graduation, OCS final military grade, OCS final academic grade).

The breadth of the selection research activity during the Korean conflict is evidenced by research on the part of the Department of Clinical Psychology of the USAF School of Aviation Medicine. Saul B. Sells directed a program which sought to develop a battery of tests which would select out those individuals, " . . . unduly predisposed to difficulties in adapting to the manifold vigors of the various stages of military flying duty." (Sells, 1956, p. 440). In that effort, a simple pass-fail criterion in flight training was rejected because a broader criterion than that of flying proficiency was desired. Post training flying proficiency was determined from personnel records and flying experience records as well as ratings of combat adjustment and objective mission and performance data collected in Korea in 1951 and 1953. In addition to the correlations between adjustment ratings in training and the combat criterion obtained in Korea which appear in Table 3.1-2, Sells and his co-workers reported correlations with the noncombat post-training criteria. These data are not included here, but they also can be used to support the contention that more than training criteria should be used in validating pilot selection instruments. (Also see Sells and Trites, 1957; Trites and Kubala, 1957; Sparks and Niess, 1956.) Another point made in the Sells work is that personality factors should be evaluated as an important component of a successful selection program.

Trites and Sells (1957) were specifically concerned with the extent to which peer ratings of performance could be used as criteria. Working on the assumption that the better pilots fly more combat and the poorer pilots fly more noncombat hours, Trites and Sells selected the number of combat hours as their objective criterion of combat performance. Also used as criteria were peer and superior ratings and psychologists' ratings. The intercorrelations between the peer-superior ratings in the combat arena and combat hours generally were positive but lower than one might expect (see Figure 3.2-2).

The effectiveness of bomber crews in Korea was evaluated for the period March to September 1951 by Hemphill and Sechrest (1952). Bombing

accuracy (circular error), sociometric nominations by crew members, and superiors' ratings were the three criteria used. Though bombing accuracy has high relevance and face validity as a criterion of combat effectiveness, it is not a perfect criterion. Hemphill and Sechrest noted three major weaknesses in that measure: (1) variable conditions under which bombing must be done; (2) limitations on measuring accurately where bombs hit; and (3) differences in the task of various crews in a bombing formation (lead crews have more tasks to perform than do the other crews). It was obvious to those researchers that superiors' ratings were strongly influenced by objective bombing data. This led the researchers to question rating data as criteria in combat settings. Data on eleven factors of aircrew performance were evaluated in that study. (See Figure 3.2-2.)

The same researchers (Sechrest and Hemphill, 1954) also evaluated motivational variables associated with the assumption of combat obligations. A group of 283 men who went overseas to combat assignments were contrasted with 57 men with the same opportunity who did not go. The following four patterns of attitudes characterized the men who went overseas: (1) general satisfaction with the Air Force; (2) more concern with opportunities for training and education; (3) less frequent somatic complaints; and (4) feelings of general social responsibility.

Naval combat research efforts during the Korea period appear, from our literature search, to be very limited. One pertinent study is noted. McGehee (1951) surveyed flight surgeons, command and training officers, and others at naval aviation installations to explore new directions for research in naval aviation. His observations and recommendations regarding pilot selection were first, that a pass-fail criterion was relied upon too heavily and should be augmented by some measure of success in the operational environment. Second, it was noted that, except at the lowest levels, less concern was shown for flying ability than for the ability to perform other military duties. McGehee recommended an analysis of critical behaviors for the various job components and selection according to the duties to be performed.

3.2.2.3 Southeast Asian Studies - Since the Korean conflict, very little attention has been allocated to personnel selection with respect to combat effectiveness. Those studies which have shed light on the subject were conducted largely for other purposes.

The Weapons System Evaluation Group (WSEG) conducted an extensive investigation of air-to-air encounters in Southeast Asia. The major purpose of this project, code named RED BARON I, was to identify research programs pertinent to the improvement of aircraft weapons. One of the six principal areas of interest was man-machine compatibility. RED BARON II, directed by the USAF Tactical Fighter Weapons Center, analyzed 625 Southeast Asia air-to-air encounters from the 1967-1968 time period as well as some data collected during the 1965-1967 RED BARON I period. In that analysis, MIG killers were shown to have more flight experience than non-killers. The RED BARON III (even later in the war) data analysis suggested however, that combat experience, not flying experience, is the more important variable in air-to-air combat success (deLeon, 1977).

Like many research activities reviewed, the RED BARON studies were not performed with the identification of pilot characteristics as a central purpose. Statements made by pilots interviewed during the RED BARON studies revealed characteristics these pilots felt were important, but these add little to the list of critical skills and characteristics which emerges from the studies that have quantitatively evaluated pilot performance in combat and other samplings of pilot opinion.

Other studies which were performed during SEA tended to be more narrowly focused. Naval Aerospace Medical Institute reports during the Southeast Asian conflict (Rickus and Berkshire, 1968, Berkshire, 1969) are representative of recent work

in the Naval selection program. Those authors advocate only the use of subjective criterion measures in the evaluation of pilot performance. Specifically, they support the use of flight surgeons as a collection point for ratings of combat performance. They state that only subjective evaluations have been able to predict pilot performance with any degree of success. The present writers must disagree with this. While subjective evaluations have been useful, the success of some objective and quantifiable criterion measures as reported by Lepley (1947) and Strawbridge and Kahn (1955) among others has established a clear precedent that quantitative criterion measures can be used effectively.

An Air Force study by Ratliff, Shore, Chiorini and Curran (1969) conducted in Southeast Asia as part of Project Combat Team attempted to determine the effects of training on F-4 second-seater combat performance. They concluded that a task inventory would be helpful in assessing the effects of training programs on combat performance. This work was followed up by a comparison of pilots and navigators in second-seat performance, and it was found that after about 30 missions no performance differences existed. (Shore, Curran, Ratliff, & Chiorini, 1970). These authors stressed the fact that they were able to obtain reliable and valid proficiency data in a combat environment. This incidental observation is quite important as it demonstrates the feasibility of research in a modern USAF combat environment.

After an assessment of critical skills, Shannon and Waag (1972, 1973) were able to develop two fleet evaluation questionnaires which were completed by F-4 squadron commanders and used as criterion measures in an analysis of fighter pilot performance in Southeast Asia. A multiple regression model using the fleet evaluations as the criterion variables and experience level, formation grade, tactics grade, Replacement Air Group grade, and a flight aptitude rating as predictor variables yielded a cumulative multiple R of .40. This was not as high as those predicting to training, but encouraging, nevertheless.

A somewhat related study which deals more with a classification problem than a selection issue is that of Miller (1974). He examined the assignment of personnel to a particular specialty such as transport, fighter, or reconnaissance (recce) based upon special predictors. Such assignment was found to be possible. Undergraduate pilot training grades and biographical data were compared with peer ratings of general competence as a pilot. For this study, certain measures which significantly predict competence in transport flying did not predict fighter pilot competence or competence as a recce pilot. The predictions can be found in Figure 3.2-3. Most striking were two UPT variables, "Contact Flying, Basic" and "Flying Training Grade." These factors (note underlined variables in Figure 3.2-3) were significantly correlated with both transport competence ratings, but the correlations were in different directions. One obvious implication of these findings is that discriminations can be made early, which would be useful for improving not only pilot selection but pilot classification in general.

Though few studies have produced data relating predictors to combat performance, numerous analytical documents have emerged. These have come primarily from officers who are students at either the Naval Postgraduate School at Monterey, California, or the Air University at Maxwell Air Force Base, Alabama.

Some of these analyses are very useful for identifying the characteristics of the successful pilot. This is true even though the conclusions are not based on quantified objective relationships between predictors and combat criteria.

Stanley (1973) used interviews and rating forms to perform a critical incident study and observed,

> "Current naval aviator selection and screening procedures are based on the individual's statistical probability of completing flight

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VARIABLE	TRANSPORT (N = 115)	FIGHTER (N = 243)	RECCE (N = 34)
AFOQT VARIABLES			
AFOQT VERBAL PERCENTILE	-0.09	-0.14*	0.28
AFOQT QUANTITATIVE PERCENTILE	-0.02	-0.11	0.39*
UPT VARIABLES			
RANK CADET ON ENTRY INTO UPT	-0.01	0.13*	-0.05
PRINCIPLES OF FLIGHT, PRIMARY	-0.33*	-0.01	-0.13
AVIATION PHYSIOLOGY, PRIMARY	-0.22*	0.03	-0.20
ENGINEERING AND SYSTEMS, PRIMARY	-0.21*	0.01	0.04
FLIGHT INSTRUMENTS,PRIMARY	-0.28*	-0.03	-0.26
NAVIGATION, PRIMARY	-0.19*	-0.09	-0.13
CONTACT FLYING, PRIMARY	-0.05	0.15*	-0.22
INSTRUMENT FLYING, PRIMARY	-0.18*	0.00	0.00
T-33 BASIC AIRCRAFT	0.15	0.11	0.25
T-38 BASIC AIRCRAFT	-0.18*	-0.11	-0.25
INSTRUMENT PROCEDURES, BASIC	-0.08	0.05	-0.06
ACADEMIC AVERAGE, BASIC	-0.20*	0.06	-0.03
NAVIGATION BASIC	-0.20*	0.06	-0.03
CONTACT FLYING, BASIC	-0.18*	0.14*	-0.06
INSTRUMENT FLYING, BASIC	-0.21*	0.06	-0.07
FORMATION FLYING, BASIC	-0.08	0.18*	-0.09
FLYING TRAINING GRADE	-0.22*	0.20*	0.02
BIOGRAPHICAL VARIABLES			
SOURCE OF COMMISSION OFFICER TRAINING SCHOOL	-0.19*	-0.11	0.00
SOURCE OF COMMISSION OTHER	0.08	0.07	0.08
YEARS OF EDUCATION BEYOND HIGH SCHOOL AT END OF UPT	-0.10	-0.16*	-0.24
FAVORABLE ATTITUDE TOWARD FIRST ASSIGNMENT AFTER UPT	0.00	0.11	0.24
ACADEMIC FIELD BUSINESS	-0.16	-0.01	-0.36*
ACADEMIC FIELD EDUCATION	-0.03	-0.13*	0.19
ACADEMIC FIELD UNSPECIFIED	0.03	0.24*	0.22

*SIGNIFICANT AT 0.05 LEVEL.

FIGURE 3.2-3 RELATIONSHIPS BETWEEN SIGNIFICANT PREDICTORS AND PERFORMANCE IN SPECIALTY AREA AS INDICATED BY PEER RATINGS (After Miller, 1974)

> training and do not determine the capability of the student to adapt to an operational environment. The resultant failure of some student aviators to complete the advanced stages of training and the ineffective performance of others in operational missions have caused a considerable financial loss and a lessening of combat readiness." (p. 2)

In his study Stanley evaluated 30 aviators. Twenty-nine of these had their combat experience (at least 25 missions) in Southeast Asia. The other subject was an Israeli Air Force pilot. Descriptions of instances (critical incidents) of effective and ineffective performance were obtained in tape recorded interviews with these aviators. Four raters independently compiled lists of behaviors which occurred during the critical incidents. After minor semantic differences were resolved, several descriptors of effective and ineffective combatants were identified. Five of these dimensions seemed potentially important for distinguishing between effective and ineffective pilots. These were situation awareness, procedural ability, decision making capacity, determination, and stress capacity.

A useful analytical study is the Air War College research report of Cook (1972). After serving in the Air Force's Air Training Command (ATC), Colonel Cook expressed concern that we have been selecting pilots for quantity in recent years. Citing his experience, he noted,

> "....I and my other check pilots began to note that the truly outstanding student--the man capable not only of performing maneuvers with a high degree of skill, but also able to make correct decisions quickly while airborne--was becoming increasingly rare. Instead, more and more students were encountered who could not cope with as simple a matter as changing the mission profile in flight to meet varying weather conditions or an unexpected area assignment.
>
> "Later, field evaluation reports gave support to these observations, and also revealed that these student deficiencies were not unique to one training base, but were being discovered throughout ATC" (Cook, 1972, pp. 10-11).

After examining specific possible weaknesses in the pilot training system, Cook had several recommendations. Important to the present research was the recommendation that present pilot selection criteria be carefully reviewed and upgraded. Included in this recommendation was possible waiving of the college degree requirement and inclusion of some measure of eagerness. The central theme of the Cook report was that the U.S. Air Force should select for quality not quantity.

Another Air University research report analyzing pilot selection in the Air Force is that of Cooper, Imaye, Karre, Robertson, Ryan, and Sakahara (1976). The theme of their analysis was that the universally assignable pilot concept is not valid and it should be replaced by a system applying operational pilot selection criteria to place pilot candidates in particular classes of planes according to their specific skills and abilities. They argue for the inclusion of psychological tests ranging from life inventories to open-ended personality tests and for psychophysiological evaluation of critical factors like susceptibility to airsickness, "G" tolerance, and altitude chamber tolerance. They also recognized the utility of simulators as selection devices, not just training devices. These pilots specified four factors which they, as a group, felt were mandatory for survival in flying fighter planes. They are motivation, aggressiveness, judgement, and reaction to stress. They felt that the four factors were not directly testable and recommended instructor pilot evaluations in these areas. The present researchers, while acutely sensitive to the difficulties associated with measuring these factors, feel that these factors are, though not without substantial development, testable. One pleasing feature of the Cooper, et al, (1976) study was that this report, produced by pilots, included a set of recommendations overlapping with ours.

3.2.3 Summary and General Implications of the Aviation Combat Studies - As stated in the introduction to Section 3.2, the research on aircrew performance in combat has been limited. Nevertheless, several important general implications emerge from the research which has been done.

Selection for combat effectiveness, not just training success, can be done. Workable criteria of combat success are available and can be recorded in an aviation combat environment, and strong precedent for aviation selection research in a combat environment has been demonstrated.

Many researchers who have performed aviation selection research were unable to validate on combat criteria adequately because no adequate data collection plan was immediately available. This tended to create a restriction so that when a plan could be approved and implemented much of the useful data were no longer available. The best possible outcome for this type of research without a well thought-out plan is to demonstrate concurrent validity, not the more desirable predictive validity.

A wide variety of predictor variables have shown promise as predictors of both objective and subjective criteria of combat success. Further

discussion of specific categories of predictors will be found in Section 4.0 in conjunction with the results of studies of nonaviation combat selection research (Section 3.3) and data from aviation selection studies which used training success for a criterion (Section 3.4).

3.3 SCIENTIFIC STUDIES OF INDIVIDUAL EFFECTIVENESS IN NON-AVIATION COMBAT AND COMBAT SURROGATES

Figure 3.3-1 shows studies of combat effectiveness conducted in non-aviation settings and research efforts on performance in simulated combat environments. It is clear if one inspects Figure 3.3-1 and contrasts it with Figure 3.2-1 that there has been a pattern of research on combat effectiveness in the nonflying military community which is different from that in the flying community. Not only is a different emphasis revealed in the two figures, but the "Army in Korea" cell of Figure 3.3-1 has more entries than any cell of either matrix making the following point clear--the army, more than any other service, has recognized the need for optimizing individual combat performance. Furthermore, there is evidence that steps have been taken to implement a combat effectiveness selection program (Helme, Willemin, and Grafton, 1974).

The combat task of the fighter pilot is generally considered more complex and intellectually demanding than the combat task of the infantryman, yet substantially more effort has been poured into evaluating the performance of the infantryman. Considering the complexity of the fighter pilot's task and the dollar value of the equipment involved, one might expect to find relatively more research into air combat effectiveness than infantry effectiveness.

Following the Korean War, combat surrogate situations were used by the Army researchers enabling them to specify the necessary critical skills and to evaluate characteristics (such as stress tolerance) which were not fully evaluated in the combat aviation studies. During periods other than the Korean conflict and immediately after, the Army selection research was reduced substantially as was selection research in the other services.

Other organizations have done relatively little research related to combat ability. A major exception to this is the work which was performed by the Office of Strategic Services during World War II (The OSS Assessment Staff, 1948).

Figure 3.3-2 shows data from studies performed in non-aviation combat and surrogate combat situations. Across the top of this figure are thirty criteria which have been used in this type of study. Along the left-hand margin are the predictors which have been evaluated. The entries are correlations except for the nomination criterion where entries are critical ratios comparing groups of soldiers nominated into upper and lower groups. A slash indicates a range of values. Combat criteria used include combat ratings, combat performance ratings, NCO and Personnel Research Branch technician ratings in combat, company commanders' ratings of combat performance, officer efficiency reports for combat duty in Korea, and combat nominations made by peers. All of these combat criteria rely upon some form of rating. Figure 3.3-2 is useful as an aid to comprehending studies cited individually in this section and as a tool for use in developing a profile of the combat effective individual (See Section 4).

3.3.1 Criterion Problems - Specification of reasonable criteria for validating a selection instrument for infantrymen or for other Army roles is inherently more difficult than specifying criteria of aviator effectiveness. In the aviation environment, some recordable measures exist (kills, rounds fired, encounters, etc.). In the infantry environment, no gun camera records or other records of individual performance are practicably available. Because of this, the researchers from the Human Resources Research Organization (HumRRO) and (what is now) the Army Research Institute for the Behavioral and Social Sciences (ARI) were forced to resort to other indices of individual combat effectiveness. After stepping through the same preliminary stages as the Navy did in World War II, these researchers decided upon criteria dependent upon information provided by the soldiers' peers. Thus, they relied on an intermediate criterion based on data collected in close temporal and spatial proximity to the actual fighting.

Another approach which was widely used in the Army research effort was to identify skills required in the combat environment and test for

	WORLD WAR II	KOREA	POST KOREA & MORE RECENT WORK
ARMY	MARSHALL, S.L.A. MEN AGAINST FIRE. NEW YORK: WILLIAM MORROW & CO., 1947. OSS ASSESSMENT STAFF. ASSESSMENT OF MEN: SELECTION OF PERSONNEL FOR THE OSS. NEW YORK: RINEHART & CO., 1948. STOUFFER, S. A., SUCHMAN, E. A., DEVINNEY, L. C., STAR, & WILLIAMS, R. M. THE AMERICAN SOLDER: ADJUSTMENT DURING ARMY LIFE, VOLUME I. PRINCETON, N. J.: PRINCETON UNIVERSITY PRESS, 1949.	BIRNBAUM, A. H., ROSENBERG, N., WHITE, R. K., & WILLEMIN, L. P. VALIDATION OF POTENTIAL COMBAT *PREDICTORS: ZI RESULTS FOR COMBAT ENGINEER (PRB* TECHNICAL RESEARCH NOTE 79). WASHINGTON, D.C.: PERSONNEL RESEARCH BRANCH, THE ADJUTANT GENERAL'S OFFICE, JULY, 1957. BIRNBAUM, A. H., WHITE, R.K., ROSENBERG, N., & WILLEMIN, L.P. VALIDATION OF POTENTIAL COMBAT PREDICTORS: ZI RESULTS FOR ARMOR (PRB TECHNICAL *RESEARCH NOTE 78). WASHINGTON, D.C.: PERSONNEL* RESEARCH BRANCH, THE ADJUTANT GENERAL'S OFFICE, JULY, 1957a. BIRNBAUM, A. H., WHITE, R.K. ROSENBERG, N., & *WILLEMIN, L. P. SELECTION AND STANDARDIZATION OF* TESTS FOR IMPROVED COMBAT APTITUDE AREAS (PRB TECHNICAL RESEARCH NOTE 87). WASHINGTON D.C.: PERSONNEL RESEARCH BRANCH, THE ADJUTANT GENERAL'S OFFICE, DEC., 1957b. DAVIS, S. W. A STUDY OF COMBAT STRESS, KOREA, 1952 (TECHNICAL MEMORANDUM ORO-T-41). CHEVY CHASE, MD.: *OPERATIONS RESEARCH OFFICE, THE JOHNS HOPKINS* UNIVERSITY, DEC., 1952. EDGERTON, H.A., & GRAHAM, W. R. THE IDENTIFICATION OF OBSERVABLE FACTORS RELATED TO SUCCESS IN COMBAT OR SIMULATED COMBAT. (PRS REPORT NO. 918). WASHINGTON, D.C.: DEPARTMENT OF THE ARMY, DEC. 1951. *EGBERT, R. L., MEELAND, T., CLINE, V. B., FORGY, E. W.,* SPICKLER, M.W., & BROWN. FIGHTER I: AN ANALYSIS OF COMBAT FIGHTERS AND NON-FIGHTERS (HUM RRO TECHNICAL REPORT NO. 44). ALEXANDRIA, VA.: HUMAN RESOURCES RESEARCH OFFICE, THE GEORGE WASHINGTON UNIVERSITY, DEC., 1957. (NTIS NO. AD–158–178). HAGGERTY, HELEN R., JOHNSON, CECIL D., & KING, SAMUEL H. *EVALUATION OF MAIL-ORDER RATINGS ON COMBAT* PERFORMANCE OF OFFICERS. PERSONNEL PSYCHOLOGY, 1959, 12, 597–605. JOHNSON, CECIL D., BURKE, LAVERNE K., LOEFFLER, JUNE C., & DRUCKER, A.J. PREDICTION OF THE COMBAT PROFICIENCY OF INFANTRYMEN (PRB TECHNICAL RESEARCH REPORT NO. 1093). WASHINGTON, D.C.: PERSONNEL RESEARCH BRANCH, THE *ADJUTANT GENERALS OFFICE,* JULY, 1955. KATTER, ROBERT V., & HOLMEN, MILTON G. INFANTRY OCS EVALUATIONS AND COMBAT PERFORMANCE (HUM RRO *TECHNICAL REPORT NO. 8). ALEXANDRIA, VA.: HUMAN* RESOURCES RESEARCH ORGANIZATION, JUNE, 1954. KATZ, A. BURKE, L.K., & KING, S. H. PREDICTION OF COMBAT EFFECTIVENESS OF OFFICER CANDIDATE SCHOOL GRADUATES (PRB TECHNICAL RESEARCH NOTE 50). WASHINGTON, D.C.: PERSONNEL RESEARCH BRANCH, THE ADJUTANT GENERAL'S OFFICE, NOV., 1955. KING, S.H., CAMPBELL, J.T., JOHNSON, C.D., KIEGER, W. A., & YAUKEY, D.W. STUDIES OF THE PERFORMANCE OF OFFICER IN COMBAT I, RELATIONSHIP OF WEST POINT MEASURES TO LATER COMBAT EFFECTIVENESS (PRS *REPORT NO. 969). WASHINGTON, D.C.: DEPARTMENT OF* THE ARMY, AUG., 1952. LYBRAND, WILLIAM A., COHEN, EDWIN, KASSEBAUM, R.G., MCGRATH, J.E., & MOLNAR, A. R. THE ASSESSMENT AND *PREDICTION OF RIFLE SQUAD EFFECTIVENESS (PRB* TECHNICAL RESEARCH NOTE 31). WASHINGTON, D.C.: PERSONNEL RESEARCH BRANCH, THE ADJUTANT GENERAL'S OFFICE, 1954a. **LYBRAND, WILLIAM A., COHEN, EDWIN, KASSEBAUM, R.G., MCGRATH, J.E., & MOLNAR, A.R. THE ASSESSMENT OF PR-**	BOYLES, WILEY R. BACKGROUND AND SITUATIONAL CONFIDENCE: THEIR RELATION TO PERFORMANCE EFFECTIVENESS. *PAPER PRESENTED TO THE MEETING OF THE* ALABAMA PSYCHOLOGICAL ASSOCIATION, BIRMINGHAM, MAY, 1968. DUBUISSON, A.V., & KLIEGER, W.A. COMBAT PERFORMANCE OF EM WITH DISCIPLINARY, RECORDS (USAPRO-TECHNICAL RESEARCH NOTE NO. 148) WASHINGTON, D.C.: U.S. ARMY PERSONNEL RESEARCH OFFICE, JUNE 1964. HELME, W. H. WILLEMIN, L. P., & GRAFFTON, F.C. PREDICTION OF OFFICER BEHAVIOR IN A SIMULATED COMBAT SITUATION (RESEARCH REPORT NO. 1182). WASHINGTON, D.C.: U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES, 1974. HIMELSTEIN, P., & BLASKOVICS, T.L. PREDICTION OF AN INTERMEDIATE CRITERION OF COMBAT EFFECTIVENESS WITH A BIOGRAPHICAL INVENTORY. JOURNAL OF APPLIED PSYCHOLOGY, 1960, 44, 1966–168. KERN, P. P. A CONCEPTUAL MODEL OF BEHAVIOR UNDER *STRESS WITH IMPLICATIONS FOR COMBAT TRAINING* (HUMRRO TECHNICAL REPORT 66–12). ALEXANDRIA, VA.: HUMAN RESOURCES RESEARCH ORGANIZATION, JUNE, 1966. (NTIS NO. AD–637–312). *PERES, SHERWOOD H. IMPLICATIONS OF RANGER TRAIN-* ING FOR FIGHTER PREDICTION (PRB TECHNICAL RESEARCH REPORT NO. 1116). WASHINGTON, D.C.: PERSONNEL RESEARCH BRANCH, THE ADJUTANT GENERAL'S OFFICE, OCT., 1959.

ARMY		MEASURES TO LATER COMBAT EFFECTIVENESS (PRS REPORT NO. 969). WASHINGTON, D.C.: DEPARTMENT OF THE ARMY, AUG., 1952. LYBRAND, WILLIAM A., COHEN, EDWIN, KASSEBAUM, R.G., MCGRATH, J.E., & MOLNAR, A. R. THE ASSESSMENT AND PREDICTION OF RIFLE SQUAD EFFECTIVENESS (PRB TECHNICAL RESEARCH NOTE 31). WASHINGTON, D.C.: PERSONNEL RESEARCH BRANCH, THE ADJUTANT GENERAL'S OFFICE, 1954a. LYBRAND, WILLIAM A., COHEN, EDWIN, KASSEBAUM, R.G., MCGRATH, J.E., & MOLNAR, A.R. THE ASSESSMENT OF INFANTRY RIFLE SQUAD EFFECTIVENESS KPRB TECHNICAL RESEARCH REPORT NO. 1087). WASHINGTON, D.C.: PERSONNEL RESEARCH BRNACH, THE ADJUTANT GENERAL'S OFFICE, 1954b. MILLER, JAMES G. THE DEVELOPMENT OF EXPERIMENTAL STRESS SENSITIVE TESTS FOR PREDICTING PERFORMANCE IN MILITARY TASKS. (PRB TECHNICAL RESEARCH REPORT NO. 1079). WASHINGTON, D.C.: PERSONNEL RESEARCH BRANCH, THE ADJUTANT GENERAL'S OFFICE, OCT., 1953. WILLEMIN, L.D., & KARCHER, E.K. DEVELOPMENT OF COMBAT APTITUDE AREAS (PRB TECHNICAL RESEARCH REPORT NO. 1110). WASHINGTON, D.C.: PERSONNEL RESEARCH BRANCH, THE ADJUTANT GENERAL'S OFFICE, JAN., 1958. WILLEMIN, L.P., & ROSENBERG, N. EVALUATION OF EXPERIMENTAL REASONING, PERCEPTUAL SPEED, AND PSYCHOMOTER TESTS FOR TRYOUTS AS COMBAT PREDICTORS (PRB TECHNICAL RESEARCH NOTE 70). WASHINGTON, D.C.: PERSONNEL RESEARCH BRANCH, THE ADJUTANT GENERAL'S OFFICE, APRIL, QOTUa. WILLEMIN, L.P., & ROSENBERG, N. VALIDATION OF POTENTIAL COMBAT PREDICTORS: ZI RESULTS FOR ARTILLERY (PRB TECHNICAL RESEARCH NOTE 77). WASHINGTON, D.C., THE ADJUTANT GENERAL'S OFFICE, JULY, 1957b. WILLEMIN, L. P., MELLINGER, J. R., & KARCHER, E.K. IDENTIFYING FIGHTERS FOR COMBAT (PRB TECHNICAL RESEARCH BRANCH, THE ADJUTANT GENERAL'S OFFICE, AUG., 1958. WILLEMIN, L.P., BIRNBAUM, A. H., & ROSENBERG, N. SELECTION OF EXPERIMENTAL PREDICTORS FOR LONGITUDINAL VALIDATION IN COMBAT ARMS (PRB TECHNICAL RESEARCH NOTE 72). WASHINGTON, D.C.: PERSONNEL RESEARCH BRANCH, THE ADJUTANT GENERAL'S OFFICE, JUNE, 1957a. WILLEMIN, L. P., BIRNBAUM, A. H., & ROSENBERG, N. VALIDATION OF POTENTIAL COMBAT PREDICTORS: RESEARCH PLAN OF LONGITUDINAL STUDY (PRB TECHNICAL RESEARCH NOTE 73). PERSONNEL RESEARCH BRANCH, THE ADJUTANT GENERAL'S OFFICE, JUNE, 1957b. WILLEMIN, L.P. ROSENBERG, N., & WHITE, R.K. VALIDATION OF POTENTIAL COMBAT PREDICTORS: ZI RESULTS FOR INFANTRY (PRB TECHNICAL RESEARCH NOTE 71). PERSONNEL RESEARCH BRANCH, THE ADJUTANT GENERAL'S OFFICE, JULY, 1957 . WILLEMIN, L. P., BIRNBAUM, A.H., ROSENBERG, N., & WHITE, R.K. VALIDATION OF POTENTIAL COMBAT PREDICTORS IN OVERSEAS MANEUVERS (PRB TECHNICAL RESEARCH NOTE 89). WASHINGTON, D.C.: PERSONNEL RESEARCH BRANCH, THE ADJUTANT GENERAL'S OFFICE, AUG., 1957.	
NAVY-MARINE		WILKINS, WALTER L. SELECTION OF MARINE CORPS PLATOON LEADERS. U.S. ARMED FORCES MEDICAL JOURNAL, 1954, 5, 1184–1191.	
AIR FORCE	TORRANCE, E.P., & ZILLER, R.C., RISK AND LIFE EXPERIENCE: DEVELOPMENT OF A SCALE FOR MEASURING RISK-TAKING TENDENCIES (AFPTRC-TN-57–23). LACKLAND AIR FORCE BASE, TEXAS: AIR FORCE PERSONNEL AND TRAINING RESEARCH CENTER, FEBRUARY, 1957. (NTIS NO. AD–989–26).		

FIGURE 3.3–1 NON-AVIATION COMBAT AND COMBAT SURROGATE STUDIES.

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PREDICTOR	STUDY	CRITERIA: LOGISTICS STAFF PERFORMANCE (OEC)	PERSONNEL STAFF PERFORMANCE (OEC)	COMBAT STAFF PERFORMANCE (OEC)	COMBAT LEADERSHIP PERFORMANCE (OEC)	PERFORMANCE IN COMBAT EXERCISES	TEST RISK (IN ADVANCED SURVIVAL COURSE)	VERBALIZED RISK (IN ADVANCED SURVIVAL COURSE)	PERCEIVED RISK (IN ADVANCED SURVIVAL COURSE)	REQUIRED ODDS (IN ADVANCED SURVIVAL COURSE)	COMPOSITE STRESS INDEX (A PRIORI)	COMBAT IN CITIES (STRESS)	JUMP TOWER (STRESS)	DARK ROOM (STRESS)	PERIMETER DEFENSE (STRESS)	ARITHMETIC & SHOCK (STRESS)	TREASURE ISLAND OIL FIRES (STRESS)	DELIBERATE ACCURACY UNDER STRESS	STRESS PERFORMANCE INDEX	AUTONOMIC EFFICIENCY (EMERGENCY REACTION)	SITUATIONAL CONFIDENCE IN FIRST ROTARY WING SOLO	SITUATIONAL CONFIDENCE IN AUTOROTATION	SITUATIONAL CONFIDENCE IN PINNACLE LANDING	OFFICER EFFICIENCY REPORT FOR DUTY IN KOREA (KATTER & HOLMAN)	NSO & PERSONNEL RESEARCH BRANCH
STATISTIC		r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r
APTITUDE																									
APTITUDE FOR SERVICE RATING, 1ST CLASS YEAR AT WEST POINT	11																								
APTITUDE FOR SERVICE RATING, 3RD CLASS YEAR AT WEST POINT	11																								
APTITUDE AREA IN	21																								
	20																								
APTITUDE AREA AE	21																								
APTITUDE AREA I	16																								
APTITUDE AREA I & OFFICER CANDIDATE TEST	9																								-.09
APTITUDE AREA CO-A	20																								
	21																								
	17																								
	18																								
	19																								
	2																								
	1																								
APTITUDE AREA CO-B	20																								
	21																								
	17																								
	18																								
	19																								
	2																								
	1																								
READING & VOCABULARY	16																								
	17																								
	18																								
	19																								
	8																								
	3																								
	2																								
	1																								
VERBAL ANALOGIES TEST	16																								
WORD GROUP TEST	16																								
ORAL KNOWLEDGE	13					.59*																			
MATH-PHYSICAL SCIENCE INFORMATION	7	.13/.22	.20/.26	.14/.37	.12/.19																				
ARITHMETIC REASONING	20																								
	16																								
	17																								
	18																								
	19																								
	8																								
	3																								
	2																								
	1																								
MECHANICAL APTITUDE	20																								
	14																								
	8																								
	16																								
	17																								
	18																								
	19																								
	1																								
	2																								
	3																								
DRIVER BATTERY I	2																								
ORGANIZED SPORTS INFORMATION	7		.18	.13																					
MECHANICAL APTITUDE SCORE MATCHED FOR EDUCATION & AGCT	14																								
INTELLECTUAL GAMES INFORMATION	7	.18	.12	.12/.15																					
INTELLECTUAL EFFICIENCY MEM	12										.10	.01	.18	.20	-.10	.06	.01	-.08	.07	.27					
ABSURDITIES TEST	16																								
NON-QUANTITATIVE MISCELLANEOUS INFO	7	.10	.10																						
GRADUATE SCHOOL POTENTIAL MEM	*12*										.15	.13	.08	.15	.08	.02	.08	.02	-.05	.21					
GT SCORE	5																								
AGCT - MATCHED FOR EDUCATION	14																								
PRACTICAL SKILLS INFORMATION	7	.17		.16/.27	.11/.18																				
INTELLIGENCE & ALERTNESS	6																								
FINANCE INFORMATION	7	.11	.13																						
HISTORY-LITERATURE CONTENT INFORMATION	7			.12																					
ECONOMICS-SOCIOLOGY INFORMATION	7	.16	.18	.11	.15																				
POLITICAL SCIENCE INFORMATION	7		.16	.10	.11																				
CLASSIFICATION INVENTORY (PRB PORTION)	20																								
CLASSIFICATION INVENTORY (HUM RRO PORTION)	20																								
CLASSIFICATION INVENTORY (TOTAL)	20																								
BIOGRAPHICAL FACTORS																									
AGE MATCHED BY EDUCATIONAL LEVEL & AGCT SCORE	9																						-.01		
EDUCATION	2																								
EDUCATION IN YEARS	5																								
EDUCATION	14																								
	14																						-.01		
FINAL CLASS STANDING OCS	9																								
ACADEMIC STANDING OCS	2																								
FIRST ACADEMIC GRADE IN OCS	5																								
FINAL ACADEMIC GRADE IN OCS	14																						.15		
TOTAL GRADE, SUM OF ALL YEARS AT WEST POINT	9																						.62		
TOTAL GRADE 1ST CLASS YEAR AT WEST POINT	9																						-.01		
TOTAL GRADE, 1ST CLASS YEAR AT WEST POINT EXCLUDING	*10*																						-.05		
APTITUDE FOR SERVICE RATING	10																								
MATHEMATICS, FINAL GRADE AT WEST POINT	11																								
ENGLISH, FINAL GRADE AT WEST POINT	11																								
MILITARY ENGINEERING FINAL GRADE AT WEST POINT																									
ELECTRICITY, FINAL GRADE AT WEST POINT	11																								
MECHANICAL, FINAL GRADE AT WEST POINT	11																								
TACTICS, 1ST CLASS YEAR GRADE AT WEST POINT	11																								
TACTICS, 3RD CLASS, YEAR GRADE AT WEST POINT	11																								
MILITARY PHYSICAL EDUCATION, 1ST CLASS YEAR GRADE AT WEST POINT	11																								
MILITARY PHYSICAL EDUCATION, 3RD CLASS YEAR GRADE AT WEST POINT	11																								
AGCT CLASS	11																								
HONOR POINT RATIO	11																								
SOCIAL STATUS	11																								
SOCIAL ADVANTAGE RACKGROUND	14																								
JOB PERFORMANCE (NON-LEADER)	12										.23	.12	.03	.22	.10	.05		.06	.00	.29					
PAY GRADE	12										.11	.09	.29	.31	.01	.07		.03	-.05	.11					
PRECYCLE VS POST CYCLE	12																								
CLASSIFICATION INVENTORY	7	.12		.02																					
BACKGROUND ACTIVITIES INVENTORY	6																								
A PRIORI KEY PERSONAL INVENTORY	2																								
KEY 2, PERSONAL INVENTORY	2																								
	20																				.08	.18	.20*		
	4																								
	5																								
	5																								
CT KEY PERSONAL INVENTORY	5																								
A PRIORI KEY SELF DESCRIPTION BLANK	5																								
CI KEY, SELF DESCRIPTION BLANK	5																								
RA VS US	2																								
MARITAL STATUS	14																								
MARITAL STATUS - MATCHED FOR EDUCATION & AGCT	14																								
SINGLE (LOW) VS MARRIED	2																								
PHYSICAL PROFILE	2																								
HEIGHT IN INCHES	2																								
WEIGHT IN POUNDS	2																								

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FIGURE 3.3-2 STATISTICAL RELATIONSHIPS BETWEEN CRITERIA OF COMBAT EFFECTIVENESS AND EVALUATED PREDICTORS FOR
OF EACH COLUMN.

DOUGLAS CORPORATION

	DELIBERATE ACCURACY UNDER STRESS	STRESS PERFORMANCE INDEX	AUTONOMIC EFFICIENCY (EMERGENCY REACTION)	SITUATIONAL CONFIDENCE IN FIRST RECAPP WING SOLO	SITUATIONAL CONFIDENCE IN AUTOROTATION	SITUATIONAL CONFIDENCE IN PINNACLE LANDING	OFFICER EFFICIENCY REPORT FOR DUTY IN NURSE (HATTER & HOLMEN)	NCO & PERSONNEL RESEARCH BRANCH TECHNICIAN RATINGS IN COMBAT	COMBAT PERFORMANCE RATING (ENTRIES GREATER THAN 1 ARE χ^2 VALUES)	COMBAT APTITUDE RATING AT END OF COMBAT TRAINING	COMBAT APTITUDE RATING IN NONCOMBAT OVERSEA MANEUVERS	COMBAT RATINGS	COMBAT NOMINATIONS
	r	r	r	r	r	r	r	r	r or χ^2	r	r	r	CR
									52*				
									40*				
											33	36	
										29/.32	35	36	
							-.09						
										17			
											.23	.17	
										29			
										.32			
										16/.30			
										.14			
										.41			
										.16			
											.24	.16	
										.29			
										.37			
										20/.30			
										.21			
										.40			
										.22			
										.27			
										.32			
											.03/.22		
								.13					
												.14	
										.02			
										.35			
										.19/.26			
										.16/.17			
												.19	
										.31/.35			
										.34			
										.35			
											.22/.30		
										11/.23			
												.20	
										.21			
										.37			
												.14	
								.13/.14	50.44**				
										.29			
										.26			
										.35			
											.17/.29		
										.34			
										.25			
												.15	
										.35			
.06	-.08	.07	.27						34.37**				
.03	.02	-.05	.21							.19/.20			
									5.79			14/.18	
													2.58
										.30/.32			
												.33	
												.31	
												.37	
						-.01							
										-.26			
									4.94			-.04/.02	
									7.04				
						-.01							
										.13			
									11.59			.01/.08	
						.15							
						.02							
						-.01							
						-.05							
									29*				
									43*				
									37*				
									.01				
									-.02				
									.10				
									.24				
									.19				
									.20				
									.25				
									.27				
									.12				
.06	.00	.29							8.42				
.03	-.05	.11											
													-1.00
											-.20		
											.19		
			.08	.18	.20*							.37	
												-.03/.07	
												.27/.32	
												.24/.29	
												.05/.09	
												.21/.31	
										.25			
									3.89*				
									6.49*				
										.04			
										.01			
										-.16			
										.08			

STUDY

1 BIRNBAUM, WHITE, ROSENBERG, & WILLEMIN (1957a)
2 BIRNBAUM, ROSENBERG, WHITE, & WILLEMIN (1957)
3 BIRNBAUM, WHITE, ROSENBERG, & WILLEMIN (1957b)
4 BOYLES (1968)
5 DUBUISSON & KLIEGER (1964)
6 EDGERTON & GRANAM (1951)
7 HELME, WILLEMIN, & GRAFTON (1974)
8 JOHNSON, BURKE, LOEFFLER, & DRUCKER (1955)
9 KATTER & HOLMEN (1954)
10 KATZ, BURKE, & KING (1959)
11 KING, CAMPBELL, JOHNSON, KLIEGER, & YAUKEY (1952)
12 MEELAND, EGBERT, & MILLER (1957)
13 PULLIAM & BATHERS (1976)
14 STOUFFER, LUMSDAINE, LUMSDAINE, WILLIAMS, SMITH, JANIS, STAR, & COTTRELL (1949)
15 TORRANCE & ZILLER (1957)
16 WILLEMIN & ROSENBERG (1957a)
17 WILLEMIN, ROSENBERG, & WHITE (1957)
18 WILLEMIN & ROSENBERG (1957a)
19 WILLEMIN, BIRNBAUM, ROSENBERG, & WHITE (1957)
20 WILLEMIN & KARCHER (1958)
21 WILLEMIN, MELLINGER, & KARCHER (1958)

McDONNELL DOUGLAS CORPORATION

AND EVALUATED PREDICTORS FOR NON-AVIATION COMBAT. INDIVIDUAL ENTRIES ARE THE STATISTIC INDICATED AT THE TOP

PREDICTOR	STUDY	CRITERIA: LOGISTICS STAFF PERFORMANCE (DEC)	PERSONNEL STAFF PERFORMANCE (DEC)	COMBAT STAFF PERFORMANCE (DEC)	COMBAT LEADERSHIP PERFORMANCE (DEC)	PERFORMANCE IN COMBAT EXERCISES	TEST RISK (IN ADVANCED SURVIVAL COURSE)	VERBALIZED RISK (IN ADVANCED SURVIVAL COURSE)	PERCEIVED RISK (IN ADVANCED SURVIVAL COURSE)	REQUIRED ZEEL (IN ADVANCED SURVIVAL COURSE)	COMPOSITE STRESS INDEX (A PRIORI)	COMBAT (IN ICTHES (STRESS))	JUMP TOWER (STRESS)	DARK ROOM (STRESS)	PERIMETER DEFENSE (STRESS)	ARITHMETIC & SHOCK (STRESS)	TREASURE ISLAND (IN FIRES) (STRESS)	DELIBERATE ACCURACY UNDER STRESS	STRESS PERFORMANCE INDEX	AUTONOMIC EFFICIENCY (EMERGENCY REACTION)	SITUATIONAL CONFIDENCE IN FIRST REPORT WING SOLO	SITUATIONAL CONFIDENCE IN AUTOROTATION	SITUATIONAL CONFIDENCE IN PINNACLE LANDING	OFFICER EFFICIENCY REPORT FOR DUTY IN KOREA
STATISTIC		r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r
SOCIAL FACTORS																								
SOCIAL PARTICIPATION	12										.09	-.04	.18	.24	-.09	.00	.13	-.10	.08	.26				
SOCIAL PRESENCE	12										.07	-.07	.28	.24	-.08	.02	.04	-.10	.05	.34				
GARRISON KEY (PRB)	20																							
COMBINED COMBAT -- GARRISON KEY (PRB)	20																							
FELLOW CANDIDATES FINAL RANKING IN OCS	10																							.41*
FELLOW CANDIDATES FIRST LEADERSHIP RANKING IN OCS	10																							.26*
FELLOW CANDIDATES FINAL LEADERSHIP RANKING IN OCS	10																							.41*
STUDENT RATING OCS	9																							.20
FELLOW CANDIDATES FIRST RANKING OCS	10																							.35*
PEER RANKINGS	13					.67- .76*																		
CONTROLLER RATING	13																							
PLATOON LEADERS FINAL RANKING IN OCS	10																							.34*
PLATOON LEADERS FIRST LEADERSHIP RANKING IN OCS	10																							.17
PLATOON LEADERS FINAL LEADERSHIP RANKING OCS	10																							.34*
PLATOON LEADER RATINGS IN OCS	9																							.17
COMPANY COMMANDER RATING IN OCS	9																							.20
PREDICTOR RATINGS	17																							
	18																							
	1																							
	2																							
PERSONALITY																								
PERSONALITY MATERIAL	3																							
PERSONALITY QUESTIONNAIRE & ARITHMETIC REASONING	19																							
PERSONALITY -- HSDB	17																							
	18																							
	1																							
	2																							
PERSONALITY QUESTIONNAIRE	19																							
PERSONALITY -- IOQ	17																							
	18																							
	1																							
	2																							
PERSONALITY -- ASDB -- IOQ	18																							
	1																							
	2																							
PERSONALITY -- GIT (POS)	17																							
	18																							
	1																							
	2																							
PERSONALITY GIT (P-N)	19																							
	17																							
	18																							
	1																							
	2																							
PSYCHOLOGICAL INTERESTS	12										.11	.12	.18	.22	-.02	.17	.01	-.01	.16	.19				
PRACTICAL SITUATIONS	16																							
PRACTICAL CONCRETENESS	7	.11		.10/.12	.14																			
CAPACITY FOR DETAIL	7				-.10																			
TOLERANCE	12										.09	.13	.17	.19	.03	.04	.11	.00	.01	.22				
RESPONSIBILITY	22										.16	.10	-.04	.10	-.11	.00	.10	-.07	.15	.15				
DOMINANCE	12										.09	.02	.09	.13	-.11	.08	.10	-.07	-.01	.23				
FEMININITY	12										.00	.17	-.22	-.13	.18	.13	-.05	.06	.13	-.06				
DELINQUENCY	12										-.01	.07	-.03	.07	.10	-.14	-.01	-.05	.06	-.07				
SCIENTIFIC ORIENTATION	7	.16	.10	.12/.24																				
MECHANICAL ORIENTATION	7					.12																		
SOCIABILITY	7				-.14																			
OUTDOOR INFORMATION	7																							
ENTERTAINMENT CULTURAL INFORMATION	7	.18	.23	.11/.17																				
HISTORICAL POLITICAL CULTURAL INFORMATION	7	.15	.27	.14/.18	.12																			
MOTIVATION (INTERESTS)																								
MILITARY INTELLIGENCE INTEREST	7		.12	-.11																1				
COMBAT ENGINEER INTEREST	7			.16	.13/.16																			
OUTDOOR INTEREST	7				.10																			
MANUAL SKILLS INTEREST	7			.13																				
MANUAL VS WHITE COLLAR INTEREST	7			.16	.17/.21																			
MEDICAL CHEMICAL INFORMATION	7	.18	.18	.17/.28	.10/.14																			
MATH SCIENCE SKILL INTEREST	7	.18	.18	.16/.27	.10																			
NON AESTHETIC INTEREST	7	.10		.11	.11/.18																			
SOCIAL SCIENCES SKILL INTEREST	7			-.12/-.15	-.13																			
SCIENTIFIC INTEREST	7	.18	.16	.16	.12/.25																			
SENSORY-MOTOR-ABILITIES																								
REACTION TO SIGNALS	16																							
	9																							
	3																							
PERCEPTUAL SPEED	16																							
PERCEPTUAL SPEED REACTION TO SIGNALS	17																							
	18																							
	1																							
	2																							
PERCEPTUAL SPEED DIALS	19																							
	17																							
	18																							
	1																							
	2																							
PERCEPTUAL SPEED -- APS 2	19																							
	16																							
	17																							
	18																							
	1																							
	2																							
PERCEPTUAL SPEED ATTENTION TO DETAIL	19																							
	17																							
	18																							
	1																							
	2																							
ATTENTION TO DETAIL (WR70)	19																							
ARMY CLERICAL SPEED	16																							
	8																							
	16																							
	17																							
	18																							
	19																							
	1																							
	2																							
TWO HAND COORDINATION	3																							
	16																							
PSYCHOMOTOR TWO HAND COORDINATION	7	.13	.12	.10/.16																				
	17																							
	18																							
	1																							
	2																							
SKILL PERFORMANCE	19																							
PSYCHOMOTOR PATTERNS	13					-.26																		
	17																							
	18																							
	1																							
	2																							
SPATIAL MOVEMENTS TEST	19																							
	8																							

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FIGURE 3.3–2 STATISTICAL RELATIONSHIPS BETWEEN CRITERIA OF COMBAT EFFECTIVENESS AND EVALUATED PREDICTORS FO
OF EACH COLUMN. (Continued)

L DOUGLAS
CORPORATION

2

STUDY	
1	BIRNBAUM, WHITE, ROSENBERG, & WILLEMIN (1957a)
2	BIRNBAUM, ROSENBERG, WHITE, & WILLEMIN (1957)
3	BIRNBAUM, WHITE, ROSENBERG, & WILLEMIN (1957b)
4	BOYLES (1958)
5	DUBUISSON & KLIEGER (1964)
6	EDGERTON & GRAHAM (1951)
7	HELME, WILLEMIN, & GRAFTON (1974)
8	JOHNSON, BURKE, LOEFFLER, & DRUCKER (1955)
9	KATTER & MOLDEN (1954)
10	KATZ, BURKE, & KING (1965)
11	KING, CAMPBELL, JOHNSON, KLIEGER, & YAUKEY (1952)
12	MEELAND, EGBERT, & MILLER (1957)
13	PULLIAM & MATHERS (1976)
14	STOUFFER, LUMSDAINE, LUMSDAINE, WILLIAMS, SMITH, JANIS, STAR, & COTTRELL (1949)
15	TORRANCE & ZILLER (1957)
16	WILLEMIN & ROSENBERG (1957a)
17	WILLEMIN, ROSENBERG, & WHITE (1957)
18	WILLEMIN & ROSENBERG (1957a)
19	WILLEMIN, BIRNBAUM, ROSENBERG, & WHITE (1957)
20	WILLEMIN & KARCHER (1958)
21	WILLEMIN, WELLINGER, & KARCHER (1958)

TREASURE ISLAND GAL FARES (STRESS)	DELIBERATE ACCURACY UNDER STRESS	STRESS PERFORMANCE INDEX	AUTONOMIC EFFICIENCY (EMERGENCY REACTION)	SITUATIONAL CONFIDENCE IN FIRST ROTARY WING SOLO	SITUATIONAL CONFIDENCE IN AUTOROTATION	SITUATIONAL CONFIDENCE (S) PINNACLE LANDING	OFFICER EFFICIENCY REPORT FOR DUTY IN KOREA	NCO & PERSONNEL RESEARCH BRANCH TECHNICIAN RATINGS IN COMBAT	COMBAT PERFORMANCE RATING	COMBAT APTITUDE RATING AT END OF COMBAT TRAINING	COMBAT APTITUDE RATING IN NONCOMBAT OVERSEAS ASSIGNMENTS	COMBAT RATINGS	COMBAT NOMINATIONS
r	r	r	r	r	r	r	r	r	r	r	r	r	CR
13	-10	08	26										
04	-10	05	34									28	
												35	
							41*						
							26*						
							41*						
							20						
							26*						
							34*						
							17						
							34*						
							17						
							20						
										53			
										64			
										64			
										70			
											19/31	.13	
										30			
										21			
										26			
										26			
											11/29		
										26			
										31			
										36			
										13			
										29			
										37			
										21			
										33			
										38			
										38			
										*3			
											15/32		
										33			
										39			
										36			
01	-01	*6	19							18			
										*0/24			
11	00	01	22										
10	-07	15	15										
10	-07	-01	23										
-05	06	13	-06										
-01	-05	06	-07										
										37/38			
								18				18	
										28/30			
										33			
										34			
										24			
										27			
											17/27		
										21			
										22			
										28			
										16			
											13/25		
										33/34			
										20			
										28			
										27			
										32			
											16/22		
										23			
										22			
										25			
										37			
											18/40		
										28/30			
								09/13					
										30/32			
										30			
										38			
											21/36		
										27			
										34		14	
										28/29			
										-			
										20			
										13			
										19			
										29			
											06/31		
										25			
										31			
										30			
										13			
								06			21/29		

OPY

SS AND EVALUATED PREDICTORS FOR NON-AVIATION COMBAT. INDIVIDUAL ENTRIES ARE THE STATISTIC INDICATED AT THE TOP

PREDICTOR	STUDY	CRITERIA: LOGISTICS STAFF PERFORMANCE (SEC)	PERSONNEL STAFF PERFORMANCE (SEC)	COMBAT STAFF PERFORMANCE (SEC)	COMBAT LEADERSHIP PERFORMANCE (SEC)	PERFORMANCE IN COMBAT EXERCISES	TEST RISK (IN ADVANCED SURVIVAL COURSE)	PERMISSIBLE RISK (IN ADVANCED SURVIVAL COURSE)	PERCEIVED RISK (IN ADVANCED SURVIVAL COURSE)	REQUIRED ODDS (IN ADVANCED SURVIVAL COURSE)	COMPOSITE STRESS INDEX (IN PRIOR)	COMBAT IN CITIES (STRESS)	JUMP TOWER (STRESS)	DARK ROOM (STRESS)	PERMITTED DISTRESS (STRESS)	KATHMATIC & SHOCK (STRESS)	TREASURE ISLAND OIL FIRES (STRESS)	DELIBERATE ACCURACY UNDER STRESS	STRESS PERFORMANCE INDEX	AUTONOMIC EFFICIENCY (EMERGENCY REACTION)	SITUATIONAL CONFIDENCE IN FIRST ROTARY WING SOLO	SITUATIONAL CONFIDENCE IN AUTOROTATION	SITUATIONAL CONFIDENCE IN PINNACLE LANDING	OFFICER EFFICIENCY REPORT FOR DUTY IN KOREA	NOD & PERSONNEL RESEARCH BRANCH QUESTIONNAIRE RATINGS OF COMBAT
STATISTIC		r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r
SENSORY–MOTOR ABILITIES (Continued)																									
INFORMATION TEST & REACTION TO SIGNAL	19																								
PATTERNS	16																								
PATTERN ANALYSIS (PA)	17																								
	18																								
	19																								
	16																								
	8																								.11/.15
	1																								
	2																								
	3																								
	20																								
IDENTICAL PICTURES	16																								.13
VISUAL CLASSIFICATION TEST	8																								
RELATED FORMS	16																								.12
HIDDEN FIGURES TEST	8																								
DIAGRAM INTERPRETATION	7	.16		.18																					
PHYSICAL EFFICIENCY TEST – DCS	9																							.04	
DISTRACTION – OBJECT COMPLETION	17																								
	18																								
	19																								
	1																								
	2																								
DISTRACTION – LOCATIONS	17																								
	18																								
	19																								
	1																								
	2																								
DISTRACTION – RECOGNITION	17																								
	18																								
	19																								
	1																								
	2																								
DISTRACTION – WEAPONS	17																								
	18																								
	19																								
	1																								
	2																								
DECISION MAKING																									
REASONING & PRACTICAL SITUATIONS	17																								
	18																								
	1																								
	2																								
	19																								
REASONING – RELATED FORMS	17																								
	18																								
	1																								
	2																								
	19																								
MEDICAL & PHYSIOLOGICAL FACTORS																									
NATURE ENDURANCE	7	.11		.13	.13/.15																				
ENDURANCE CRAWL	7				.12																				
PHYSICAL FITNESS	16																								
PHYSICAL CAPACITIES	6																								
READY DECISION MAKING	7		.14		.12																				
LEADERSHIP																									
LEADERSHIP (SQUAD LEVEL)	6																								
READINESS TO LEAD	7			.11																					
PHYSICAL LEADERSHIP	7				.12																				
COMBAT LEADER ORIENTATION	7				.11/.19																				
OUTDOOR SKILL & COMBAT LEADERSHIP	7			.12	.19/.23																				
ADMINISTRATIVE LEADERSHIP	7			–.13																					
ADMINISTRATIVE SUPERVISION	7			–.10																					
ADMINISTRATIVE INTEREST	7	–.11		–.16/–.18	–.12/–.18																				
REACTION UNDER FIRE	6																								
ORDERLINESS	6																								
MILITARY BEARING																									
CONDUCT (3RD CLASS YEAR GRADE AT WEST POINT)	11																								
TAUT SHIP COMMAND	7	–.10																							
MILITARY SKILLS																									
COMBAT KEY (PRB)	20																								
COMBAT KEY (HUM RRO)	20																								
MILITARY TACTICS – INFORMATION	7	.13	.22	.16/.22	.16/.22																				
TECHNICAL OPERATIONS INFORMATION	7	.29	.20	.22/.38	.14/.21																				
TECHNICAL CONTENT INFORMATION	7	.12		.14/.21	.12																				
SUPPLY INFORMATION	7	.11	.14	.11/.12																					
AUTOMOTIVE INFORMATION	8																								.10/.19
	16																								
	17																								
	18																								
	19																								
	1																								
	2																								
	3																								
ARMY CLERICAL SPEED & AUTOMOTIVE INFORMATION	19																								
GENERAL INFORMATION TEST & AUTOMOTIVE INFORMATION	19																								
REACTION TO SIGNALS & AUTOMOTIVE INFORMATION	19																								
ATTENTION TO DETAIL AND AUTOMOTIVE INFORMATION	19																								
SHOP MECHANICS (SM)	8																								.10/.19
	16																								
	17																								
	18																								
	19																								
	1																								
	2																								
	3																								
ARMY RADIO CODE	8																								.12/.20
	16																								
	17																								
	18																								
	19																								
	1																								
	2																								
	3																								
ELECTRICAL INFORMATION	8																								.07/.11
	16																								
	17																								
	18																								
	19																								
	1																								
	2																								
	3																								
RADIO INFORMATION	8																								.03/.11
	16																								
	17																								
	18																								
	19																								
	1																								
	2																								
	3																								
M1 RIFLE	9																							.05	
COMBAT INTEREST	7			.11/.15	.12																				
RISK TAKING																									
REVISED RISK SCALE	15						.34**	.22	.28*	–.34*															

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FIGURE 3.3–2 STATISTICAL RELATIONSHIPS BETWEEN CRITERIA OF COMBAT EFFECTIVENESS AND EVALUATED PREDICTORS FOR N
OF EACH COLUMN. (Continued)

STRESS PERFORMANCE INDEX	AUTONOMIC EFFICIENCY (EMERGENCY REACTION)	SITUATIONAL CONFIDENCE IN FIRST ROTARY WING SOLO	SITUATIONAL CONFIDENCE IN AUTOROTATION	SITUATIONAL CONFIDENCE ON 5 PINNACLE LANDING	OFFICER EFFICIENCY REPORT FOR DUTY IN KOREA	NDC & PERSONNEL RESEARCH BRANCH TECHNICIAN RATINGS IN COMBAT	COMBAT PERFORMANCE RATING	COMBAT APTITUDE RATING AT END OF COMBAT TRAINING	COMBAT APTITUDE RATING IN NONCOMBAT OVERSEA MANEUVERS	COMBAT RATINGS	COMBAT NOMINATIONS
r	r	r	r	r	r	r	r	r	r	r	CR
								.17 .23 .27 .25 .37 .09 .23 29/.33	21/.35 13/.29 11/.16 17/.32 22/.26 09/.24	.15 .14	
					.34	11/.15 .13 .12		.14 .13 .28 .15 .19 .24 .29 .30 .18 .33 .25 .10 .18 .14 .18 .17			
								.28 .20 .30 .39 .22 .31 .26 .17	18/.24 12/.21		
								.03			-4.79
											7.60 -7.60 0.44
							.07				
						10/.19 10/.13 12/.20 07/.11 03/.11		.27 .29 .37 .34 .17 .25 .29 .39 .34 .06 .22 .17 .17 .30 .17 .18 .26 .12 .23 -.14 .12 .12 -.06 .02 .13	26/.38 29/.43 28/.40* 31/.41* 28/.43* 27/.30 05/.17 16/.23 03/.72	.34 .34 .16 .15 .16 .09 .07	
					.05						

STUDY

1 BIRNBAUM, WHITE, ROSENBERG, & WILLEMIN (1957a)
2 *BIRNBAUM, ROSENBERG, WHITE, & WILLEMIN (1957)*
3 BIRNBAUM, WHITE, ROSENBERG, & WILLEMIN (1957b)
4 BOYLES (1968)
5 DUNNIGAN & KLIEGER (1964)
6 EDGERTON & GRAHAM (1951)
7 HELME, WILLEMIN, & GRAFTON (1970)
8 JOHNSON, BURKE, LOEFFLER, & DRUCKER (1955)
9 KATTER & HOLMEN (1956)
10 KATZ, BURKE, & KING (1955)
11 *KING, CAMPBELL, JOHNSON, KLIEGER, & YAUKEY (1952)*
12 MEELAND, EGRERT, & MILLER (1957)
13 PULLIAM & MATHERS (1976)
14 STOUFFER, LUMSDAINE, LUMSDAINE, WILLIAMS, SMITH, JANIS, STAR, & COTTRELL (1949)
15 TORRANCE & ZILLER (1957)
16 WILLEMIN & ROSENBERG (1957a)
17 WILLEMIN, ROSENBERG, & WHITE (1957)
18 WILLEMIN & ROSENBERG (1957a)
19 WILLEMIN, BIRNBAUM, ROSENBERG, & WHITE (1957)
20 WILLEMIN & KARCHER (1958)
21 WILLEMIN, MELLINGER, & KARCHER (1958)

PY

LUATED PREDICTORS FOR NON-AVIATION COMBAT. INDIVIDUAL ENTRIES ARE THE STATISTIC INDICATED AT THE TOP

them. An example of this is the investigation of performance in stressful environments. The specific criterion problems faced by the various research groups will be considered in conjunction with the discussion of specific programs.

3.3.2 World War II Studies - During World War II, the Research Branch, Information and Education Division, United States Army, performed extensive research on the combat soldier (Stouffer, Suchman, DeVinney, Star and Williams, 1949). Unlike what was to follow in Korea, measures of combat effectiveness were not recorded at the front lines. However, the studies performed in World War II laid the groundwork for later studies by creating more respect within the military heirarchy for personnel research. The World War II researchers studied personal adjustment, job satisfaction, and attitudes. The general focus was on the individual as a member of a social system. Many factors noted in that extensive description of the soldier undoubtedly influence combat effectiveness, but specific research about individual combat effectiveness was not included in that work. Just as the Army Air Force's Aviation Psychology Program drew together many leading experimental psychologists, this World War II study of the infantryman drew upon the best research personnel resources available, and prominent sociologists and social psychologists were included.

One of the most thoughtful treatments of the combat effectiveness of the individual soldier was that of S. L. A. Marshall, the Army historian of the European Theater of Operations. One point he makes which must be kept in mind is that men change character under fire. Because of this, any adequate selection program must be validated against the ultimate criteria, performance in combat. Training success could not possibly include the stress associated with the immediate threat of death. As Marshall put it,

> "The near presence of death and the prospect of meeting it at the next moment move men in many curious ways. Many men seem to change character under the guns. The life of hardship and of danger gives new strength to the truly strong and greater weakness to the truly weak. The erstwhile fatalist may become the most superstition-ridden man in a company. The dreamer may become a realist. The backward man may come forward. The arrogant may develop new bounds of compassion. The 'natural born leader' may lose his vital spark. All men who have known battle have seen such strange transformations." (Marshall, 1947, p. 184)

A major World War II personnel research effort which has strongly influenced social psychology in the last 30 years is that of the Office of Strategic Services (OSS). The personnel selection work of the OSS, while not directed toward selecting combat performers as conventionally defined, was clearly aimed at selecting people who should be able to work in high stress, combat-like situations. In applying their "scientific art of arriving at sufficient conclusions from insufficient data" (the OSS Assessment Staff, 1948, p. 8), the OSS psychologists identified seven major general behavioral variables and three additional special or task specific variables. The general variables were (1) motivation for assignment, (2) energy and initiative, (3) effective intelligence, (4) emotional stability, (5) social relations, (6) leadership, and (7) security. The special factors were physical ability, observing and reporting, and propaganda skills.

A unique aspect of the OSS work was the precedent set when holistic testing was used effectively as part of the selection routine. Holistic testing enabled the selection team to create a stressful test situation which would not be possible without such extensive control of the test environment. Unfortunately, no systematic validation of this selection program was ever undertaken, so the ten factors listed above are only at the level of clinical observation. The OSS staff was aware of this shortcoming. They said,

> "In establishing the OSS assessment unit, we erred in not making provision from the start for validation studies. No member of the staff then had time to devote to the crucial task of organizing a system of appraisal. When we finally came to it, there was no time for anything but a makeshift. Thus, we failed to construct an adequate standard for

> evaluating our work, and at the end are left speculating in the valley of uncertainty." (The OSS Assessment Staff, 1948, p. 448)

3.3.3 Research During and Immediately Following the Korean Conflict - Seeking to identify factors related to the success or failure of infantrymen in combat and to establish hypotheses about possible predictors of combat success, Edgerton and Graham (1951) embarked on a broad based research project. They surveyed numerous historical documents for statements descriptive of combat behavior. In addition, combat seasoned Marines and Army infantrymen were interviewed. The interviews and literature search yielded about 1100 statements describing combat behavior from which Edgerton and Graham developed a forced choice rating instrument.

Edgerton and Graham (1951) originally planned to validate their selection instrument on intermediate criteria based upon training performance; but with the outbreak of fighting in Korea, they sought a good combat criterion. Not having a practicable objective criterion of combat success, Edgerton and Graham settled for a tentative criterion. That criterion consisted of soldiers naming fellow squad members with whom they would (favorable) or would not (unfavorable) like to enter combat. Ratings for 927 Korean veterans were provided by 569 respondents.

Descriptions of favorably nominated soldiers tended to focus on leadership, social behavior, intelligence, and alertness, whereas descriptions of unfavorably nominated soldiers tended to focus on their reactions under fire or their lack of physical capacities.

Edgerton and Graham (1951) had outlined plans for cross validation of their forced choice selection instrument, but were unable to complete that work. Other scientists within the Army personnel research community continued this class of research.

Three major Army selection research programs were conducted in Korea. First was that of the Personnel Research Branch of the Adjutant General's Office which relied heavily on NCO ratings of combat effectiveness. Second was that of the Operations Research Office (ORO) of Johns Hopkins University which focused on physiological stresses associated with combat. The ORO work (Davis, 1952) however, does not fit in the mainline of the present research. Third was the research effort by the HumRRO team which used a peer nomination technique.

Prior to the Personnel Research Branch (PRB) effort during the Korean conflict, research in a ground combat zone had generally been considered impracticable (King, Campbell, Johnson, Klieger, and Yaukey, 1952). The PRB investigators sought actively to conduct research where face-to-face contact with those experiencing infantry combat was possible. Aside from generating the specific data about the nature of the combatants, the PRB program demonstrated effectively that research near the front lines is possible. King, et al, noted that,

> ". . . one definite and important conclusion can already be stated concerning the accomplishments of these studies as a whole. Success in obtaining the research data has demonstrated that profitable personnel research can be conducted in a combat setting with a minimum of inconvenience to military operations." (1952, p.iii)

Using ratings obtained from superior officers, King, et al, (1952) sought to examine the possible link between performance at West Point and rated combat effectiveness. When 43 company grade officers who were academy graduates were studied, relatively high validity coefficients were noted. The best of the 15 predictors considered was the Aptitude for Service Rating ($r = .52$) which was assigned during the senior year at West Point.

The Officer Efficiency Report (OER) score for service in the combat zone served as the criterion of combat effectiveness for Katz, Burke, and King (1955). Those researchers studied a sample of 90 company grade officers who were graduates of Infantry Officer Candidate School (OCS) in 1951. Peer rankings in OCS yielded the highest predictive

relationship, r = .34; academic grades in OCS were of little value, r = -.05 to -.01. Peer rankings were very useful in another study. Wilkins (1954) indicated that the best predictor of how a Marine platoon leader in combat will be judged for effectiveness by his superior is the estimate of his fellow candidates before he is commissioned.

Johnson, Burke, Loeffler, and Drucker (1955) studied the 5th Cavalry Regiment and 35th Infantry Regiment in Korea in 1951 and developed a combat self-description blank on which soldiers answered multiple choice items about biographical information and indicated preferred personal characteristics. A modified version of this self-description blank was used in other studies by PRB researchers. Haggerty, Johnson, and King (1959) were able to use "Mail-order" ratings to get combat performance estimates for West Point graduates.

Near the end of 1953, the PRB initiated research to identify the most promising of a large number of new experimental combat predictors and to validate those predictors in a longitudinal study involving approximately 4000 soldiers. Before this longitudinal work was undertaken, the discrepancy between intermediate and ultimate criteria was carefully considered by the PRB group. Willemin, Rosenberg, and White (1957) believed that intermediate criteria could augment the "in war" research. Discussing this, Willemin, Rosenberg, and White stated,

> "The ultimate criterion to use in validating potential combat selection tests is one collected at the front lines. Nevertheless, research on combat selection was continued long after the Korean hostilities ceased because it was firmly believed that criteria derived in carefully selected training and maneuver situations could materially supplement a front line criterion. Although elements of stress and realistic danger, including the 'will to fight,' are more readily tapped in the combat situation, non-combat tactical situations may provide sampling of characteristics not easily measured in combat." (1957,p. 1)

The most promising predictors found in the longitudinal studies have since been incorporated into the Army's combat arms aptitude tests (Helme, et al, 1974). After the longitudinal study was outlined, variables were selected and then separately validated on intermediate criteria for each of the four combat arms branches, infantry, armor, combat engineers, and artillery (e.g., Birnbaum, Rosenberg, White, and Willemin, 1957; Birnbaum, White, Rosenberg, and Willemin, 1957a).

The development of potentially useful perceptual, psychomotor, and reasoning tests for use in the PRB studies was performed by Willemin and Rosenberg (1957a). Since it was a developmental step, the Willemin and Rosenberg work used intermediate criteria in the form of Combat Aptitude Ratings which required an estimate of combat potential and a rank ordering of squad members in an advanced combat training environment. These preliminary efforts identified several predictors. Descriptions of the more widely used PRB predictors (e.g., Attention to Detail Test or Weapons Identification Test) are included in Appendix 3.B. Those descriptions might be useful in interpreting portions of Figure 3.3-2.

When evaluating the Korean studies of the PRB group and the HumRRO team in an attempt to refine the newly defined directions in the Army selection research, Willemin, Birnbaum, and Rosenberg (1957a) noted that, ". . . the best results for efficient combat classification were most likely to come from measuring not only technical skills and abilities but also such factors as personality, motivation, interest, and attitudes (p. 1)." The Willemin, Birnbaum, and Rosenberg evaluation resulted in the selection of 16 predictor instruments for use in a longitudinal study of infantrymen. The coefficients for the Willemin, Birnbaum, and Rosenberg (1957b) study which are reported in Figure 3.3-2 tend to be positive and around .20. The strongest coefficients, besides the fifth week predictor (peer) ratings which yielded an r of .57, were Arithmetic Reasoning, .34; Reaction to Signals, .33; and the General Information Test, .33. One of the conclusions of the infantry validation study conducted in the United States was that personality

factors added substantially to the selection package.

The preliminary validation studies performed in the United States for other combat specialties showed minor differences from the preliminary infantry validation study. For all four combat specialty areas, the strongest predictor was the peer rating taken during the fifth week of training (Willemin and Rosenberg, 1957b; Birnbaum, White, Rosenberg, and Willemin, 1957a, 1957b; Birnbaum, Rosenberg, White, and Willemin, 1957).

Most of the troops studied in the United States were also studied in overseas maneuvers one year later. Willemin, Birnbaum, Rosenberg, and White (1957) reported validity coefficients based upon an intermediate criterion which was the combat aptitude rating administered in overseas maneuvers. These coefficients appear in a column near the right of Figure 3.3-2. The overseas validity analyses were very much in agreement with the earlier state-side analyses. Although the absolute value of the coefficients was somewhat lower in the overseas study, the two instruments which appeared to have the greatest generalized validity in the overseas analyses were the personality questionnaire and the General Information Test.

At the conclusion of the seven-year PRB effort to improve the Army Classification Battery, which had included the study of approximately 1000 soldiers in Artic maneuvers, 2000 in Korean combat, and 2000 in peacetime, some firm conclusions could be appropriately drawn. Most important were: (1) the need for the inclusion of personality material in combat arms selection batteries, and (2) the need for interest area information in the selection batteries (Willemin and Karcher, 1958). The latter appeared most pertinent for "Masculine Interests." The data reported for the Willemin and Karcher study (study 20 in Figure 3.3-2) are in some cases partially redundant with earlier PRB reports, but the study incorporates some of the HumRRO data. The new batteries were tried out on 1500 new recruits, and these tests were shown to be useful in improving the overall classification of personnel (Willemin, Mellinger, and Karcher, 1958).[1]

The largest single research effort on infantryman performance was that by Egbert, Meeland, Cline, Forgy, Spickler, and Brown (1957) in the, so called, Fighter I program. These HumRRO researchers, under contract to the Department of the Army, sought to develop psychological descriptions of fighters and nonfighters who served in Army combat units in the Korean conflict. If an adequate set of descriptors could be developed, then these could serve as aids in the development of Army selection devices.

Egbert, et al, (1957) studied very good combat performers in hopes of more readily identifying differentiating traits. Six hundred and forty-seven soldiers from the 45th, 2nd, and 7th infantry Divisions were interviewed during the summer of 1953 and asked to identify two or three soldiers they would most and least want to fight alongside and to describe incidents from combat that led to those selections. The interviewees were told that they were being asked to provide this information so that it could be used for preparing others for combat. From the interview data, 310 infantrymen were selected. They were adminstered a 40-hour battery of tests in Korea in the fall of 1953. To be in the upper criterion group, one had to be cited as a good performer by two or more interviewees, or he had to be cited by one interviewee and also be recommended for a decoration for valor in combat. Lower criterion group members either were selected as poor performers by interviewees or classed themselves as inadequate performers.

Egbert, et al, (1957) were acutely aware that interviewer bias and experimenter bias could distort their findings, but the use of data only from the extreme performers served to reduce this. The 40-hour test battery yielded several hundred variables on which the two criterion groups were

[1]Other related studies coming out of the PRB include Miller (1953); Lybrand, Cohen, Kassebaum, McGrath, and Molnar (1954a, 1954b).

compared. The predictors evaluated by Egbert, et al, were quite often very obscure and too numerous to include reasonably with other studies in Figure 3.3-2. They are included in Appendices 3.C and 3.D and are considered not only a valuable augmentation of the data in Figure 3.3-2 but a reflection of one of the most thorough evaluations of predictor variables with potential for distinguishing the combat effective from the ineffective.

Following extensive analyses, Egbert, et al, (1957) summarized their findings with the following 11 statements:

a. The fighter is more intelligent.
b. The fighter is more masculine.
c. The fighter is a doer.
d. The fighter is more socially mature.
e. The fighter is preferred by his peers.
f. The fighter has greater emotional stability.
g. The fighter has leadership potential.
h. The fighter has better health and vitality.
i. The fighter had a more stable home life.
j. The fighter has a greater fund of military knowledge.
k. The fighter exhibits greater speed and accuracy on performance tests.

During the 1960s HumRRO undertook an analysis of behavior under stress. Kern (1966) proposed that an individual's stress resistance is related to his confidence in a particular situation or situational test. Boyles (1968) used Situational Confidence Measures with a Background Activities Inventory to evaluate confidence at various points in helicopter training. Situational confidence appears to be a potentially useful concept for describing one area of the combatant's performance.

Katter and Holmon (1954), working for HumRRO, performed research to determine which evaluation devices used in Infantry OCS were useful in predicting the future performance of junior officers in combat units. The goal of this work was to identify screening devices which could be used to improve the combat effectiveness of Infantry officers. Three pre-OCS measures and eight measures taken during OCS were correlated with OCS class standing and with combat performance in Korea as reflected in combat ratings. Detailed comments provided by the commanding officers (OER) of 139 Infantry OCS graduates were used to rate their effectiveness. Additional ratings were obtained for 120 OCS graduates serving in the 45th Division. The 11 measures and their correlations with the two criteria are shown in Figure 3.3-3. The entries in the "correlation with combat performance" column are redundant with entries from the Katter and Holmon study appearing in Figure 3.3-2.

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PREDICTERS	CORRELATION WITH FINAL OCS CLASS STANDING*	CORRELATION WITH COMBAT PERFORMANCE
OCS MEASURES		
STUDENT RATING	0.61	0.20
COMPANY COMMANDER RATING	0.75	0.20
PLATOON LEADER RATING	0.63	0.17
FINAL CLASS STANDING	–	0.15
DEMERITS	0.29	0.07
M1 RIFLE QUALIFICATION CATEGORY	0.10	0.05
PHYSICAL EFFICIENCY TEST	0.04	0.04
ACADEMIC STANDING	0.86	0.02
PRE-OCS MEASURES		
AGE	0.03	–0.01
EDUCATION	0.06	–0.01
AAI AND OCT	0.20	–0.09

*AN AVERAGE OF STUDENT RATING, COMPANY COMMANDER RATING, AND ACADEMIC STANDING.

FIGURE 3.3-3 CORRELATIONS BETWEEN OCS RATINGS AND COMBAT PERFORMANCE (After Katter & Holmon, 1954)

Of special interest here is a comparison of the two columns of Figure 3.3-3. The correlations between the predictors and the combat ratings are generally lower than those between the predictors and success in OCS. A striking difference exists between the two criteria and their relationship with academic standing. Of course, academic standing is one of the determiners of final class standing, so the .86 correlation between the two is inflated. Nevertheless, a large difference exists in the correlations between academic standing and the two criteria. Academic standing in OCS was not shown to predict combat performance.

Torrance and Ziller (1957) drew upon the findings of Torrance, Rush, Kohn, and Doughty (1957) and the HumRRO work (Egbert, et al, 1957) which had illustrated the importance of risk-taking to combat effectiveness and tried to validate a risk-taking scale of a biographical inventory. The subjects in this study were 370 combat aircrew personnel, yet this stressful combat surrogate did not involve combat aviation. The intermediate criteria were four measures derived from a test given in the Advanced Survival Course. The test consisted of nine problem-solving field test situations under threat of "punishment" for wrong choices. The four measures were Test Risk, the total number of high risk choices; Verbalized Risk, the frequency of expressed willingness to experience the more dangerous alternative; Perceived Risk, based upon specific item choices; and Required Odds, a measure of the percentage of minimum chance of success required by a subject before he would select the most dangerous alternative. "Individuals scoring high on the Risk Scale tended to take more risks on tests by guessing, to perceive less risk in accomplishing dangerous tasks, and to require lower odds in choosing a dangerous alternative than do individuals scoring low on the scale." (Torrance and Ziller, 1957, p. 5)

Himelstein and Blaskovics (1960) developed a risk scale for a biographical data blank and found that, for Army ROTC cadets, the scale was useful for indicating an intermediate criterion of combat effectiveness.

3.3.4 More Recent Work - In an attempt to identify characteristics of those who are unwilling to perform adequately or unable to perform because of disciplinary problems, Dubuisson and Klieger (1964) analyzed data collected during the Korean war to determine if a relationship existed between combat performance and court-martial convictions. For this restricted sample, the relationship between various predictors and combat ratings are included in Figure 3.3-2. The relationship between the combat rating and an honorable discharge was significant for enlistees. This supported the belief that the nonoffender is a better combat soldier. This also indirectly refutes the often believed notion that many characteristics associated with the stereotypical convict are also the characteristics of the combat fighter; it is actually the other way around.

In a study using "Field" observational techniques, Peres (1959) identified several characteristics to be tested in fighter prediction. Peres entered a high stress environment, the U.S. Army Ranger Course, as a participant observer. Having kept a detailed record of his observations and experiences, he specified ten constellations of reactions which might have potential for differentiating good and poor fighters. These are malingering, lack of social responsibility, martyrdom, unauthorized withdrawal, hostility, fear of injury, uneasiness over the unknown, psychotic-like reactions, failure to assume the combat role, and inability to follow instructions.

Helme, et al, (1974) of the Army Research Institute have recently attempted to develop measures predictive of leadership performance in combat and have validated those measures preliminarily against a set of situational criterion tasks designed to reflect a combat environment. These researchers developed the Differential Officer Battery (DOB) which included measures of information ranging from military tactics and technology to physical sciences, social sciences, arts, and sports. Also included were life inventory questions. The eight factors for the DOB which appeared to be the most important for leadership in the Helme, et al, (1974) study, in order of importance, are (1) general knowledge, (2) mechanical technology, (3) scientific potential, (4) combat leadership, (5) administration, (6) managerial control, (7) personal adjustment, and (8) organized sports. Predictor (DOB scale) correlations with Officer Evaluation Center performance measurements appear in Figure 3.3-2.

3.3.5 Summary and Evaluative Comments - We have reviewed the nonaviation combat and the combat surrogate studies. The review reveals that the Army has done substantially more research pertaining to selection for combat effectiveness than the other services. The data indicate that selecting for specific combat duties can be done which, in turn, improves force readiness. It was also found that peer and superior ratings augment other selection methods quite well.

The nonaviation combat effectiveness studies, then, have directly addressed basic selection problems which have not been seriously considered for fighter pilot selection since the Korean conflict. The selection work conducted by the Army research community provides substantial data of value in developing a fighter pilot combat effectiveness selection program.

3.4 FIXED WING PILOT SELECTION STUDIES FOR THE PREDICTION OF SUCCESS IN TRAINING

Since the advent of World War II, a large number of studies has been conducted with the goal of identifying factors important in the prediction of success in military aviation training. From some 800 titles and abstracts reviewed, approximately 200 articles focusing upon pilot selection techniques were chosen for discussion in this report. Although studies related to nonpilot or nonaviation specialties such as officer effectiveness[1], pilot instructor proficiency[2], and ROTC/academy success[3] were also reviewed, this research will not be discussed due to its limited potential value for the prediction of pilot training success.

Pilot selection studies are of two major types, rotary wing research, and fixed wing research. Statistical results of rotary wing research are summarized in Appendix 3.E. Most of the studies reviewed are of the fixed wing type. These include studies done within the United States Air Force, Navy, and Army, and within foreign and private pilot programs dating from World War II to the present time.

Although a large variety of criteria for success in training has been employed, a dichotomous pass-fail type of measure has been favored. Among these are:

1. Pass-Fail/Attrite (frequently defined as pass versus elimination due to flight deficiency, fear, or own request; eliminations for physical or administrative reasons are sometimes also included in the fail/attrite category)
2. Administrative Elimination[4]
3. Airsickness Elimination[4]
4. Fear of Flying Elimination[4]
5. Flight Failure Elimination[4]
6. Medical Elimination[4]
7. Motivational Elimination (fear of flying and voluntary withdrawal eliminations)[4]
8. "Not Aeronautically Adapted" Elimination (Hutchins, 1964)[4]
9. "Not Physically Adapted" Elimination (Hutchins, 1964)[4]
10. "Purified Pass-Fail" (graduated from training and "good adjustment" versus failure due to "poor motivation, excessive emotional reaction or overt symptoms attributable to stress in the program," Sells, 1956)
11. Tension Elimination (anxiety)[4]
12. Tension or Airsickness Elimination[4]
13. Voluntary Withdrawal Elimination[4]
14. Voluntary Withdrawal or Flight Failure Elimination[4]
15. Voluntary Withdrawal versus Flight Failure Elimination.

Less frequently used criteria are criterion group membership (student versus instructor, aviation officer candidate versus college student; aviation officer candidate versus drop on request, adjusted versus maladjusted, and type of aircraft or pilot assignment), number of board appearances, frequency

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[1] Barron, Block, MacKinnon, et al, (1958); Gough (1958); Gough and Krauss (1958); Hollander (1964); Lichtenstein and Hahn (1962); MacKinnon (1958); MacKinnon, Crutchfield, Barron, et al, (1958); Suttell (1955); Thorndike and Hagen (1958); Tupes (1957a); Tupes (1957b); Tupes (1959); Tupes (1963); Tupes and Christal (1957); Tupes, Carp and Borg (1957); Vinacke (1956); Wherry, Stander and Hopkins (1959); Woodworth and MacKinnon (1957); Woodworth and MacKinnon (1958); Woodworth, Barron and MacKinnon (1957).

[2] Cox and Christal (1956); Gallagher (1958); Johnson and Berkshire (1960); Mullins and Cox (1959); Tucker (In Perry, 1967).

[3] Creager and Miller (1960); Krumboltz (1957); Miller (1960a); Miller (1960b); Miller (1961); Miller and Creager (1960); Tupes and Kaplan (1961b).

[4] These groups are contrasted with all other candidates or successful candidates. For example, the Administrative Elimination Criterion refers to Pass/Other versus Administrative Elimination.

of airsickness and vertigo experiences, grades (academic, flight, military, and overall), military/leadership rank, motivational measures (e.g., desire to enter pilot training), stage of attrition, and time to solo or complete training.

In addition to the criterion used, studies have also been organized by the type of predictor employed. At a general level, predictors may be classified into two types: (1) those dealing with characteristics, e.g., general aptitudes, traits; and (2) those dealing with critical skills for piloting proficiency, e.g., performance on job samples and light planes.

Correlation (r)[5] and multiple correlation (R)[6] have been the most popular statistics employed. Statistical tests used are t[7], F[7], and χ^2[8].

Reviews of research focusing on characteristics, critical skills, and multiple prediction are presented in Sections 3.4.1, 3.4.2, and 3.4.3, respectively. Caution should be exercised in interpreting this literature, especially in cases where repeated statistical testing is found. This statistical problem, as well as methodological issues, is discussed in Section 3.4.4. Summary statements may be found at the end of each subsection as well as in Section 3.4.5.

3.4.1 Characteristics - Included in this category are aptitude, biographical, medical, motivational, personality, stress, and social factors. Relationships between these predictors and the criteria noted previously (Section 3.4) are reviewed in Sections 3.4.1.1 through 3.4.1.7.

3.4.1.1 Aptitude Factors - Studies using aptitude measures as predictors of success in training are summarized in Figure 3.4-1. Included in this figure are those studies which have reported statistical results.[9]

During World War II, the Army Air Force's Psychology Program was established to develop a full-scale program for the selection of aircrew personnel. Under this program, two testing instruments, largely consisting of aptitude material, were devised. One of these was the Army Air Force's Qualifying Examination (AAFQE) which was used as a preliminary screening device. This exam included tests for comprehension and judgment, mathematical ability, mechanical comprehension, and observational judgment (DuBois, 1947; Flanagan, 1948; Miller, 1947). One of the best sources of validity data for the AAFQE is provided by a study done with approximately 1300 unselected men sent into pilot training during World War II.[10] These trainees were tracked through advanced training. Correlations of .46 (mechanical comprehension) and .50 (composite) were reported using the pass-fail criterion (DuBois, 1947; Flanagan, 1948).

Another major development during World War II was the Aircrew Classification Battery (ACB). This instrument was used for the classification of aircrew into specialties such as navigator, bombardier, and pilot (DuBois, 1947; Flanagan, 1948; Miller, 1947). In addition to individual test scores, stanines[11] were also obtained. In the study with 1300 unselected men sent into pilot training, correlations ranged from .29 to .49 for the individual tests using the pass-fail criterion. Correlations

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[5]The degree of relationship between a predictor and a criterion (correlation coefficient).

[6]The degree of relationship between two or more predictors (combined) and a criterion (multiple correlation).

[7]Tests of differences between means.

[8]A test of association between variables consisting of frequency data.

[9]In the research reviewed, the predictors were not studied in combination with all criteria. Therefore, this figure, like others in this section, contains empty cells. A slash indicates that a range of values is being reported. Significance levels are indicated when they have been reported by the author(s). Due to the variety of statistics employed and the large number of studies reviewed, signifcance levels were not computed when they were absent from the literature. For example, several types of correlations have been used - the Pearson product-moment correlation, Spearman rank-order correlation, biserial correlation, point-biserial correlation, and phi.

[10]Pilot trainees who had not been screened.

[11]Stanines are normalized scores with a mean of five, a standard deviation of approximately two and a range of 1 to 9. The word stanine became associated with aircraft specialty tests, but has subsequently been used generally.

N = SAMPLE SIZE
NS = $p > .05$
* = $p \leq .05$
** = $p \leq .01$

REFERENCE AND STATISTIC	PREDICTOR	CRITERION: PASS-FAIL ATTRITE	ADMINISTRATIVE ELIMINATION	AIRSICKNESS ELIMINATION	FEAR OF FLYING ELIMINATION	FLIGHT FAILURE ELIMINATION	GROUND FAILURE ELIMINATION	MEDICAL ELIMINATION	MOTIVATIONAL ELIMINATION	NOT AERONAUTICALLY ADAPTED ELIMINATION	NOT PHYSICALLY ADAPTED ELIMINATION	PUNITIVE PASS-FAIL	TENSION ELIMINATION	TENSION AND AIRSICKNESS ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP: STUDENT-GRADUATION	CRITERION GROUP: AVIATION OFFICER CANDIDATE - COLLEC STUDENT	CRITERION GROUP: AVIATION OFFICER CANDIDATE - DROP ON REQUEST	CRITERION GROUP: ADJUSTED - MALADJUSTED	CRITERION GROUP: AIRCRAFT-PILOT ASSIGNMENT	EXPERIENCE OF MOTION SICKNESS/ AIRSICKNESS	EXPERIENCE OF HEPTAD
BALE AND AMBLER (1971) [r, N = 602]	AVIATION QUALIFYING TEST MECH. COMPREHENSION TEST	05 NS 18 **																							
BERKSHIRE AND AMBLER (1963) [r, N = 196]	AVIATION QUALIFYING TEST FLIGHT APTITUDE RATING	15 23				14 21	26 05								18 42										
DUBOIS (1947) FLANAGAN (1948) [r, N = 1137]	ARMY--AF QUALIFYING EXAM: MECH. COMPREHENSION TOTAL AIRCREW CLASSIFICATION BATTERY: READING COMPREHENSION MECHANICAL PRINCIPLES GENERAL INFORMATION MATHEMATICS A MATHEMATICS B BOMBARDIER STANINE NAVIGATOR STANINE PILOT STANINE	46 50 31 42 49 30 29 52 53 64																							
FLEISCHMAN, AMBLER, PETERSON AND LANE (1966) [r, N = 575--643]	AVIATION QUAL TEST MECH. COMPREHENSION TEST	03 NS 01 NS				07 NS 00 NS												-01 NS 01 NS							
FLYER AND BIGBEE (1955a) [r, N = 130]	AIR FORCE OFFICER QUALIFYING TEST: PILOT STANINE	58 **																							
GREENE (1947) [r, N = 88]	SELF ADMINISTERING TEST OF MENTAL ABILITY TEST OF MECH. COMPREHENSION																								
KAPLAN (1965) [r, N = 740--1245] [r]	ARMY FIXED WING APTITUDE BATTERY: MECH. PRINCIPLES COMPOSITE FLIGHT APTITUDE SELECTION TEST--COMPOSITE	21/27 32/41 39/46				22 32																			
LANE (1947) [r, N = 37]	SELF ADMINISTERING TEST OF MENTAL ABILITY TEST OF MECH. COMPREHENSION																								
LEMASTER AND GRAY (1974) [r, N = 71]	AIR FORCE OFFICER QUALIFYING TEST: PILOT PERCENTILE NAVIGATOR PERCENTILE QUANTITATIVE PERCENTILE QUALITATIVE PERCENTILE OFFICER QUAL. PERCENTILE	 16 NS 10 NS -07 NS -19 * -09 NS																							
LEVINE AND TUPES (1952) [r, N = 448--596]	AIRCREW CLASSIFICATION BATTERY: PILOT STANINE	 57	49			60/63			34/56																
MARTOCCIA AND KELLY (1957) [r, N = 211--300]	MECH. COMPREHENSION TEST FLIGHT APTITUDE RATING AVIATION QUALIFYING TEST															1.00 NS 1.00 NS 1.00 NS									
MCGREVY AND VALENTINE (1974) [r, N = 221]	AIR FORCE OFFICER QUALIFYING SUBTESTS	37 NS				32 NS																			
MICHAEL (1949) [r, N = 356--815]	AIRCREW CLASSIFICATION BATTERY:	42/60																							
MILLER (1966b) [r, N = 1185--2737]	AIR FORCE OFFICER QUALIFYING TEST: PILOT COMPOSITE NAVIGATOR--TECH. COMPOSITE OFFICER QUAL. COMPOSITE	 18 **/26 ** 18 **/19 ** 09 **/12 **			07 NS/25 ** 01 NS/27 ** -03 NS/-11NS	18 **/22 ** 11 **/13 ** 04 NS			04/13 NS 00/05 NS 04 NS/16 *	10 */26 ** 12 **/28 ** 02 NS/12 *						11 */20 * 19 */22 ** 06/13 NS									
MILLER (1969) [r, N = 1500]	AIR FORCE OFFICER QUALIFYING TEST: PILOT COMPOSITE NAVIGATOR--TECH. COMPOSITE OFFICER QUAL. COMPOSITE	 46 * 18 * 12 *			42 * 27 * 11 NS	36 * 11 * 04 NS			24 * 00 NS 16 *						37 * 19 * 11 NS										
MULLINS AND COX (1960) [r, N = 537--618]	AIR FORCE OFFICER QUALIFYING TEST: PILOT COMPOSITE	 12 **				14 **									03 NS										
TUPES, BOWLES, AND TORR (1955) [r, N = 206]	AVIATION CADET--OFFICER CANDIDATE QUAL. TEST: CURRENT AFFAIRS ENGLISH USAGE PRACTICAL JUDGMENT ARITHMETIC REASONING																								
TUPES AND CHRISTAL (1957) [r, N = 276]	AIR FORCE OFFICER QUALIFYING TEST: OFFICER APTITUDE																								
VALENTINE (1961) [r, N = 151--172]	COLLEGE ENTRANCE EXAM BOARD COMPOSITES: QUANTITATIVE APTITUDE INTERMEDIATE MATHEMATICS HIGH SCHOOL RANK AIR FORCE OFFICER QUALIFYING TEST: OBSERVER--TECH COMPOSITE PILOT COMPOSITE OFFICER QUALITY COMPOSITE READING COMPREHENSION VOCABULARY GENERAL KNOWLEDGE GENERAL SCIENCE ARITHMETIC REASONING GENERAL MATHEMATICS MECHANICAL INFORMATION MECHANICAL PRINCIPLES	 -03 00 -13 -06 13 14 20 18 45 34 -04 -09 -11 00 -03 -12 -10 -17 12 03 05 03 -07 -06 31 24 28 21				04 00 -05 -08 15 19 25 13 51 38 -06 -09 -18 -08 -08 -14 -18 22 -04 -08 13 04 -10 -14 35 21 24 14																				

FIGURE 3.4–1 STATISTICAL RESULTS OF FIXED WING PILOT SELECTION STUDIES RELATING APTITUDE MEASURES TO CRITERIA OF

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CORPORATION

CRITERION																			
FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP STUDENT INSTRUCTION	CRITERION GROUP AVIATION OFFICER CANDIDATE - COLLEGE STUDENT	CRITERION GROUP AVIATION OFFICER CANDIDATE - DROP ON REQUEST	CRITERION GROUP ADJUSTED - MALADJUSTED	CRITERION GROUP AIRCRAFT PILOT ASSIGNMENT	EXPERIENCE OF MOTION SICKNESS/ MISCOORDINATES	EXPERIENCE OF VERTIGO	GRADES - ACADEMIC	GRADES - FLIGHT	GRADES - MILITARY	GRADES - OVERALL	MILITARY LEADERSHIP MANN	MOTIVATIONAL MEASURES	STAGE OF ATTRITION	TIME TO SOLO OR COMPLETE TRAINING	TRAINING PHASE
																			FLIGHT
									51 22	12 40	35 35							FLIGHT
																		THROUGH ADVANCED
01 NS 01 NS																		FLIGHT
																		THROUGH BASIC
										-16 NS/ 31** -07 NS/ 38**								FLIGHT
																		FLIGHT
										-37/ 18 -30/ 32								FLIGHT
										-06/ 15 NS -07/ 10 NS 06/ 15 NS -15/ 05 NS -15/ -01 NS								T-37
																		BASIC
															7 16 ** 14 46 ** 1 56 NS			THROUGH ADVANCED
																		TRAINING
																		TRAINING
									37 **/ 41 ** 47 ** 42 **/ 43 **	23 **/ 28 ** 17 **/ 20 ** 10 **/ 12 **	11 **/ 15 ** 12 **/ 16 ** 21 **							TRAINING
									48 * 47 * 42 *	33 * 20 * 10 *	18 * 16 * 21 *							TRAINING
																		LIGHT PLANE
														05 NS 06 NS 07 NS 10 *				FLIGHT
									63									AIR FORCE ACADEMY
									31 19 12	-18 -21 02								PRIMARY BASIC PRIMARY BASIC PRIMARY BASIC
									27 15 31 -20 22 -02 21 29 20 11 17	-13 -07 -22 -13 -20 -17 -08 -16 -06 -07 -15								PRIMARY BASIC PRIMARY BASIC PRIMARY BASIC PRIMARY BASIC PRIMARY BASIC PRIMARY BASIC PRIMARY BASIC PRIMARY BASIC PRIMARY BASIC PRIMARY BASIC

APTITUDE MEASURES TO CRITERIA OF SUCCESS IN TRAINING

for the bombaridier, navigator, and pilot stanines, respectively, were .52, .53, and .64 (DuBois, 1947; Flanagan, 1948). Similarly, high correlations have been obtained in other studies. Using the pilot stanine, Levine and Tupes (1952) found correlations of .57 with the pass-fall criterion, .49 with the administrative elimination criterion, .60 to .63 with the flight failure elimination criterion, and .24 to .56 with the motivational elimination criterion in basic training. Michael (1949) obtained correlations ranging from .42 to .60 with the pass-fail criterion in training.

Since this initial major effort, several other tests with aptitude components have been devised. Fairly high correlations have been reported for the Flight Aptitude Rating (FAR) which is based upon scores for mechanical and spatial abilities. Berkshire and Ambler (1963) reported correlations ranging from .05 to .42 with pass-fail type criteria and .22 to .40 with grades in Naval flight training. Although Martoccia and Kelly (1957) failed to find differences in FAR scores between voluntrary withdrawal and flight failure eliminations, those who attrited in later stages of training (later basic and advanced) had higher FAR scores than those who attrited earlier (presolo).

Promising correlations have also been obtained with two Army tests, the Army Fixed Wing Aptitude Battery (AFWAB) and the Flight Aptitude Selection Test (FAST). For the AFWAB, correlations with the pass-fail criterion ranged from .32 to .41. The correlation with the flight failure elimination criterion was .32. Similarly, FAST scores had correlations ranging from .39 to .46 with the pass-fail criterion in flight training (Kaplan, 1965).

With other aptitude test measures, mixed results have been reported. One of these tests is the Air Force Officer Qualifying Test (AFOQT) (Miller, 1966b; Miller, 1968; Miller, 1970; Miller and Valentine, 1964; Valentine, 1960). This test is composed of 13 subtests from which five composites are computed. These are the pilot, navigator-technical, officer quality, verbal, and quantitative composites. In most studies reviewed, fairly high validity coefficients have been reported (Flyer and Bigby, 1955a; Miller, 1966a; Miller, 1959; Mullins and Cox, 1960; Tupes and Christal, 1957; Valentine, 1961) using both pass-fail type criteria and training grades. For example, Flyer and Bigbee (1955a) reported a correlation of .58 between the pilot composite and the pass-fail criterion through basic training; and Valentine (1961), using the pilot composite, found correlations of .45 and .51 with the pass-fail criterion and the flight failure elimination criterion, respectively, in primary training. Miller (1969) reported significant correlations ranging from .18 to .48 using the pilot composite and grades in training. Although the majority of studies have reported promising validity coefficients for the AFOQT, two studies reviewed have reported negative findings. LeMaster and Gray (1974) investigated the relationship between the five composites and two criteria in T-37 training (pass-fail and flight grades). Only one of ten correlations reached significance, and this correlation was negative. McGrevy and Valentine (1974) computed multiple correlations between AFOQT scores and two criteria in training (pass-fail and flight failure elimination). Both correlations failed to reach significance.

Other aptitude measures which have yielded inconsistent results are College Entrance Examination Board Scores (Valentine, 1961), and scores on the Aviation Cadet Officer Qualifying Test (Tupes, Bowles, and Torr, 1955), the Aviation Qualifying Test (Bale and Ambler, 1971; Berkshire and Ambler, 1963; Fleischman, Ambler, Peterson, and Lane, 1966; Martoccia and Kelly, 1957), Mechanical Comprehension Tests (Bale and Ambler, 1971; Fleischman, et al, 1966; Greene, 1947; Lane, 1947; Martoccia and Kelly, 1957), and the Self Administering Test of Mental Ability (Greene, 1947; Lane, 1947).

In summary, substantial correlations have been obtained with several aptitude measures. These are the AAFQE, the ACB, the FAR, the AFWAB, and the FAST battery. The highest correlations were reported with the pilot stanine of the ACB developed during World War II.

3.4.1.2 Biographical - Several instruments have been devised to secure biographical information to predict success in training. As can be seen from Figure 3.4-2, this type of measure shows some potential for predicting training success.

Bale and Ambler (1971) and Fleischman, et al, (1966) have related scores on the Biographical Inventory to measures of success in flight training. Bale and Ambler (1971) obtained a statistically significant correlation (r = .14) with the pass-fail criterion. Correlations reported by Fleischman, et al, (1966) were .15, .13, and .10 with the pass-fail, flight failure elimination, and voluntary withdrawal elimination criterion, respectively.

Many test batteries also contain biographical components. The Aircrew Classification Battery included two biographical scores: (1) Biographical Data: Navigator, and (2) Biographical Data: Pilot. In an unselected sample of pilot trainees during World War II, Biographical Data: Navigator correlated .11 and Biographical Data: Pilot correlated .31 with the pass-fail criterion (DuBois, 1947; Flanagan, 1948).

The Air Force Officer Qualifying Test contains a Pilot Biographical Inventory and an Officer Quality Biographical Inventory. Scores on the former had correlations of .18 to .21 with the pass-fail criterion and .17 to .24 with the flight failure elimination criterion in primary and basic training (Valentine, 1961). However, the Pilot Biographical Inventory had low correlations with basic training grades (r = .00 with academic grades; r = .10 with flight grades). The Officer Quality Inventory had consistently low correlations with all criteria (r = -.04 to .09).

Included in the Army Fixed Wing Aptitude Battery is a Background Inventory. Correlations found were .15 to .20 with the pass-fail criterion and .18 with the flight failure elimination criterion in flight training (Kaplan, 1965).

The final inventory reviewed is the ROTC Personal Inventory. Scores on this test were found to be unrelated to motivation for flying training (application for pilot or aircraft observer training) (Tupes, et al, 1955).

Academic grades constitute one biographical variable which has been found valuable for predicting success in training. Several studies have found significant relationships between preflight grades and training criteria (Booth, 1968; Fleischman, et al, 1966; Hollander, 1952; Martoccia and Kelly, 1957). For example, Fleischman, et al, (1966) reported statistically significant correlations ranging from .12 to .18 with the pass-fail criterion and from .13 to .26 with the flight failure elimination criterion. Correlations with the voluntary withdrawal elimination criterion were not significant (r = .04 to .07). Additionally, Hollander (1952) found correlations ranging from .12 to .49 between grades and pass-fail in basic training.

Undergraduate Pilot Training (UPT) grades also predict success in training (Bale, Rickus, and Ambler, 1973; Cooper, Imaye, Karre, Robertson, Ryan, and Sakahara, 1976). For example, Cooper, et al, (1976) obtained a correlation of .30 with flight grades in the Replacement Air Unit. Other grades which have shown relationships to training criteria are primary academic grades (Peterson and Pomarolli, 1966) and U.S. Naval Academy grades (Ambler and Kiernan, 1963). Finally, two types of grades demonstrated little promise as predictors of success in training. These are college grade point average (Bale and Ambler, 1971) and military science grade (Tupes, et al, 1955).

A second important predictor is military rank. Hutchins (1964) studied the relationship of rank of incoming officers to three criteria: (1) pass-fail, (2) type of attrition (ground failure elimination, voluntary withdrawal elimination, flight failure elimination, not aeronautically adapted elimination, not physically adapted elimination, and other elimination) and (3) stage of attrition. Greater attritions occurred among higher ranking officers, primarily with respect to voluntary withdrawal elimination. No differences were obtained with the third criterion.

[1] THESE GROUPS ENTERED INTO THE COMPUTATION OF ONE x^2 TEST.

N = SAMPLE SIZE
NS = $p > .05$
* = $p \leq .05$
** = $p \leq .01$

REFERENCE AND STATISTIC	PREDICTOR	CRITERION: PASS-FAIL ATTRITE	ADMINISTRATIVE ELIMINATION	AIRSICKNESS ELIMINATION	FEAR OF FLYING ELIMINATION	FLIGHT FAILURE ELIMINATION	GROUND FAILURE ELIMINATION	MEDICAL ELIMINATION	MOTIVATIONAL ELIMINATION	NOT AERONAUTICALLY ADAPTED ELIMINATION	NOT PHYSICALLY ADAPTED ELIMINATION	PURIFIED PASS-FAIL	TENSION ELIMINATION	TENSION AND AIRSICKNESS ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL - FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP: STUDENT—INSTRUCTOR
BALE AND AMBLER (1971) [r, N = 602]	BIOGRAPHICAL INVENTORY	.14 **																	
	COLLEGE MAJOR (MATH, PHYSICS, ENG., MIL.ACAD)	.08 NS																	
	COLLEGE MAJOR(BUSINESS, ECON., HIST, POL. SCI.)	-.02NS																	
	COLLEGE POPULATION> 16,000	.07 NS																	
	ATTENDED 3 OR MORE COLLEGES	-.09 NS																	
	GRADE POINT AVERAGE 2.0–2.49	.10 NS																	
	GRADE POINT AVERAGE 2.5–2.99	-.08 NS																	
	CHANGED MAJOR< TWICE	.02 NS																	
	COLLEGE IN EAST, SOUTH, CENTRAL	-.02 NS																	
	COLLEGE IN PACIFIC STATE	.09 NS																	
	FLOWN < TWICE COMMERCIALLY	.03 NS																	
	FLOWN > 9 HRS. COMMERCIALLY	.01 NS																	
	FLOWN LIGHT PLANE, NOT SOLO	.01 NS																	
	SOLOED LIGHT PLANE, NO PRIVATE LICENSE	.03 NS																	
	HAS PRIVATE LICENSE	.11*																	
	HAS COMMERCIAL LICENSE	.08 NS																	
	MEMBER COLLEGE FLYING CLUB	.00 NS																	
	AGE MOTIVATED FLY IN MILITARY:																		
	22 OR OLDER	-.08 NS																	
	18–21	.01 NS																	
	15–17	.10 NS																	
	12–14	.01 NS																	
	YOUNGER THAN 12	.02 NS																	
	NEVER SURE	.01 NS																	
BOOTH (1968) [r, N = 812-1122]	AVIATION OFFICER CANDIDATE SCHOOL GRADES	.20/.25																	
	FLIGHT PREPARATION SCHOOL GRADES	.26/.35																	
COOPER, IMAYE, KARRE, ROBERTSON, RYAN, AND SAKAHARA (1976) [r, N = 33]	UNDERGRADUATE PILOT TRAINING ACADEMIC AND FLYING GRADES																		
DUBOIS (1947)	BIOGRAPHICAL DATA:NAVIGATOR	.11																	
FLANAGAN (1948) [r, N = 1137]	BIOGRAPHICS DATA:PILOT	.31																	
	AGE	.03																	
	EDUCATION	.20																	
	PREVIOUS FLYING EXPERIENCE	.28																	
FLEISCHMAN, AMBLER, PETERSON, AND LANE (1966) [r, N = 575-643]	PREFLIGHT GRADES:																		
	PRINCIPLES OF FLIGHT	.15**				.18**									.07 NS				
	NAVIGATION	.18**				.26**									.05 NS				
	ENGINES	.16**				.23**									.04 NS				
	PHYSICAL TRAINING	.12**				.13**									.07 NS				
	BIOGRAPHICAL INVENTORY	.15*				.13**									.10*				
HOLLANDER (1952) [r, N = 299]	PREFLIGHT GRADES:																		
	FINAL:AEROLOGY	.36**																	
	FINAL:CODE	.43**																	
	FINAL:ENGINES	.12 NS																	
	FINAL:NAVAL SERVICE	.20*																	
	FINAL:NAVIGATION	.49**																	
	FINAL:PRIN. OF FLIGHT	.30**																	
	NAVY GRADE (PRE-FLIGHT AVER. GR.)	.45**																	
HUTCHINS (1964) [X^2, N = 1636]	RANK	8.92**				12.27**[1]	12.27**[1]			12.27**[1]	12.27**[1]				12.27**[1]				
KAPLAN (1965) [r, N = 740-1245]	ARMY FIXED WING APTITUDE BATTERY:																		
	BACKGROUND INVENTORY	.15/.20				.18													
LANE (1947) [r, N = 37]	BIOGRAPHICAL INVENTORY																		
MARTOCCIA AND KELLY (1957) [F, N = 211-300]	PREFLIGHT GRADES:																		
	AERONAUTICS																1.00 NS		
	ENGINEERING																1.00 NS		
	NAVAL ORIENTATION																4.42*		
	NAVIGATION																14.08**		
	PRINCIPLES OF FLIGHT																1.00 NS		
	READING IMPROVEMENT																17.99**		
	PHYSICAL TRAINING																11.19**		
	MILITARY TRAINING																7.69**		
	GROUND FINAL GRADE																7.74**		
	OFFICER-LIKE QUAL.																10.20**		
	PREFLIGHT FINAL GRADE																11.92**		
	AGE																1.00 NS		
	EDUCATION																1.00 NS		
TUPES, BOWLES AND TORR (1955) [r, N = 212-213]	MILITARY SCIENCE GRADE																		
	ROTC PERSONAL INVENTORY																		
VALENTINE (1961) [r, N = 151-172]	AIR FORCE OFFICER QUALIFYING TEST:																		
	PILOT BIOGRAPHICAL INVENTORY	.21				.24													
		.18				.17													
	OFFICER QUAL. BIOGRAPH. INV.	.09				.01													
		-.03				.01													
WAAG, SHANNON AND AMBLER (1973) [χ^2 N = 1276]	PROCUREMENT	7.65**																	

FIGURE 3.4–2 STATISTICAL RESULTS OF FIXED WING PILOT SELECTION STUDIES RELATING BIOGRAPHICAL MEASURES TO CRITERI

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CRITERION																					
TENSION AND AIRSICKNESS ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL – FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP STUDENT–INSTRUCTOR	CRITERION GROUP AVIATION OFFICER CANDIDATE – COLLEGE STUDENT	CRITERION GROUP AVIATION OFFICER CANDIDATE – DROP ON REQUEST	CRITERION GROUP ADJUSTED–MALADJUSTED	CRITERION GROUP AIRCRAFT/PILOT ASSIGNMENT	EXPERIENCE OF MOTION SICKNESS/ AIRSICKNESS	EXPERIENCE OF VERTIGO	GRADES–ACADEMIC	GRADES–FLIGHT	GRADES–MILITARY	GRADES–OVERALL	MILITARY/LEADERSHIP RANK	MOTIVATIONAL MEASURES	STAGE OF ATTRITION	TIME TO SOLO OR COMPLETE TRAINING	TRAINING PHASE
																					FLIGHT
																					FLIGHT
													.30								REPLACEMENT TRAINING UNIT
																					THROUGH ADVANCED
	.07 NS .05 NS .04 NS .07 NS .10*																				FLIGHT
																					BASIC
	12.27**1																	1.72 NS			THROUGH ADVANCED
																					FLIGHT
													-.31/47								FLIGHT
			1.00 NS 1.00 NS 4.42* 14.08** 1.00 NS 17.99** 11.19** 7.69** 7.74** 10.20** 11.92** 1.00 NS 1.00 NS															3.09* 2.54 NS 4.43* 3.76* 4.30* 18.08** 1.00 NS 2.04 NS 7.68** 3.37* 8.53** 1.10 NS 2.75 NS			THROUGH ADVANCED
																	-.03 NS .05 NS				FLIGHT
												.00 -.04	.10 -.01		3.24**						PRIMARY BASIC PRIMARY BASIC TRAINING

APHICAL MEASURES TO CRITERIA OF SUCCESS IN TRAINING

Procurement source also appears to be a valuable predictor of succes in training (Waag, Shannon, and Ambler, 1973, Wherry and Hutchins, 1964). For example, Waag, et al, (1973) studied the relationship between two procurement sources and two criteria: (1) pass-fail, and (2) presolo training grades. Procurement sources were Aviation Officer Candidates (civilians) and Officers under Instruction (commissioned officers). Significant differences were obtained with both criteria, with greater failures and lower training grades for the officer group.

Previous flying experience is a fourth variable related to success in training (Ambler, 1955; Bale and Ambler, 1971; DuBois, 1947; Flanagan, 1948). Bale and Ambler (1971) found a moderately low but statistically significant correlation between possession of a private pilot's license and the pass-fail criterion in flight training (r = .11). Similarly, during World War II, in the study with an unselected sample of pilot trainees, a correlation of .28 was obtained between prior flying experience and the pass-fail criterion (DuBois, 1947; Flanagan, 1948).

Other biographical variables investigated, but for which conflicting findings or low correlations have been reported, are age (Bair, 1952; DuBois, 1947; Flanagan, 1948; Martoccia and Kelly 1957), education (Bair, 1952; DuBois, 1947; Flanagan, 1948; Martoccia and Kelly, 1957), college major (Bale and Ambler, 1971; Peterson and Lane, 1966), college population and location and age at which the candidate became motivated to fly in the military (Bale and Ambler, 1971).

In summary, biographical inventories appear to show promise for the prediction of pilot training success. Variables showing relationships with training criteria are academic grades, military rank, procurement source, and previous flying experience. The value of other biographical variables such as age, education, and college major for predicting aviation training success is questionable.

3.4.1.3 Medical - As can be seen in Figure 3.4-3, studies reviewed in this domain focused upon physical fitness test scores as predictors.[12] Overall, these scores seem to be unrelated to success in pilot training. This is undoubtedly due, at least in part, to the fact that there is a restricted range since those in poor health have not been in the samples studied.

Graybiel and West (1945) investigated the relationship of two physical proficiency tests to flight grades at two stages of training (primary and intermediate stages). These tests were the Pack Test and the Composite Fitness Test. None of these correlations reached significance (r = .00 to .09). Similarly, Tupes, et al, (1955) found little relationship between scores on the ROTC Proficiency Test Battery and motivation for flying training (r = -.02 to -.05). Valentine (1961) reported low negative correlations between the Physical Aptitude Exam scores and the pass-fail criterion in primary and basic training, the flight failure elimination criterion in primary and basic training, and academic and flight grades in basic training (r = -.12 to .00).

Substantial correlations were obtained in only one study reviewed. Krumboltz (1957) found significant multiple correlations between seven physical fitness predictors (height; weight; medicine ball throw; pullups; hop, step, and jump; hurdle run; and 250 yard shuttle run) and a peer rating of leadership (R = .17 to .36). The obvious difference in this study as contrasted with others is the criterion measure used. Other studies have used a pass-fail type of criterion or grades as measures of success in training.

In conclusion, these data suggest that physical proficiency measures are largely unrelated to many criteria of success in training.

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[12] Other types of physical tests have been developed, such as strength and cardiovascular tests (Bender, Kobes, Salmon, and Pierson, 1965) and electrocardiographic stress tests (Smith, 1964a; Smith, 1964b). In addition, tests are available for the detection of medical anomalies such as the Wolff-Parkinson White Syndrome (Smith, 1964c). However, these studies did not address the validity of these variables for success in training.

N = SAMPLE SIZE
NS = $p > .05$

REFERENCE AND STATISTIC	PREDICTOR	CRITERION: PASS-FAIL/ATTRITE	ADMINISTRATIVE ELIMINATION	AIRSICKNESS ELIMINATION	FEAR OF FLYING ELIMINATION	FLIGHT FAILURE ELIMINATION	GROUND FAILURE ELIMINATION	MEDICAL ELIMINATION	MOTIVATIONAL ELIMINATION	NOT AERONAUTICALLY ADAPTED ELIMINATION	NOT PHYSICALLY ADAPTED ELIMINATION	PURIFIED PASS-FAIL	TENSION ELIMINATION	TENSION AND AIRSICKNESS ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL - FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP STUDENT-INSTRUCTOR
GRAYBIEL AND WEST (1945) [r, N = 1076]	PRIMARY PACK TEST																		
	PRIMARY COMPOSITE FITNESS TEST																		
	INTERMEDIATE STEP TEST																		
	INTERMEDIATE COMPOSITE FITNESS TEST																		
TUPES, BOWLES, AND TORR (1955) [r, N = 190-193]	ROTC PHYSICAL PROFICIENCY TEST BATTERY																		
	DIPS																		
	SHUTTLE RUN																		
	BASKETBALL THROW																		
VALENTINE (1961) [r, N = 151-172]	PHYSICAL APTITUDE EXAMINATION	-.04 .00				-.07 -.12													

FIGURE 3.4–3 STATISTICAL RESULTS OF FIXED WING PILOT SELECTION STUDIES RELATING MEDICAL MEASURES TO CRITERIA OF SUCCESS IN TRAINING

N = SAMPLE SIZE
NS = $p > .05$
* = $.01 \leq p \leq .05$
** = $p < .01$

REFERENCE AND STATISTIC	PREDICTOR	CRITERION: PASS-FAIL/ATTRITE	ADMINISTRATIVE ELIMINATION	AIRSICKNESS ELIMINATION	FEAR OF FLYING ELIMINATION	FLIGHT FAILURE ELIMINATION	GROUND FAILURE ELIMINATION	MEDICAL ELIMINATION	MOTIVATIONAL ELIMINATION	NOT AERONAUTICALLY ADAPTED ELIMINATION	NOT PHYSICALLY ADAPTED ELIMINATION	PURIFIED PASS-FAIL	TENSION ELIMINATION	TENSION AND AIRSICKNESS ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL - FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP STUDENT-INSTRUCTOR
BUCKY AND BURD (1970) [F, N = 87]	MASLOW'S HIEARCHY OF NEEDS														5.14*				
DUBOIS (1947) [r, N = 1137]	STRENGTH INTEREST:BOMBARDIER	-.05																	
	STRENGTH INTERST:NAVIGATOR	.09																	
	STRENGTH INTEREST:PILOT	.04																	
FRENCH (1956) [r, N = 344]	TEST OF INSIGHT																		
GREENE (1947) [r, N = 88]	DESIRE TO FLY INVENTORY																		
LANE (1947) [r, N = 37]	DESIRE TO FLY INVENTORY																		
PETERSON, LANE, AND KENNEDY (1965) [r, N = 100-128]	EDWARDS PERSONAL PREFERENCE SCHEDULE:																		
	ACHIEVEMENT					-.04 NS									-.05 NS	-.06 NS			
	DEFERENCE					-.04 NS									.03 NS	.00 NS			
	ORDER					.17 NS									.03 NS	.10 NS			
	EXHIBITION					-.08 NS									-.02 NS	-.05 NS			
	AUTONOMY					.03 NS									.15 NS	.12 NS			
	AFFILIATION					.05 NS									-.12 NS	-.06 NS			
	INTRACEPTION					-.02 NS									-.18 NS	-.13 NS			
	SUCCORANCE					.02 NS									.18 NS	.13 NS			
	DOMINANCE					.19 NS									.14 NS	.18*			
	ABASEMENT					-.22*									.02 NS	-.09 NS			
	NURTURANCE					.02 NS									-.01 NS	-.01 NS			
	CHANGE					.19 NS									.06 NS	.13 NS			
	ENDURANCE					.09 NS									-.15 NS	-.07 NS			
	METEROSEXUALITY					-.08 NS									.09 NS	.02 NS			
	AGRESSION					-.11 NS									.12 NS	.03 NS			
RICKUS AND AMBLER (1967) [F, N = 707]	STAGE OF TRAINING																		
SELLS (1956) [r, N = 200-451]	AVIATION INTEREST KEY											.33/.41							
[r, N = 400]	PILOT OPINIONAIRE											.11/.28							
TUPES, BOWLES, AND TORR (1955) [r, N = 213]	ATTITUDE SURVEY - MILITARY																		
	ATTITUDE SURVEY - FLYING																		
	ATTITUDE SURVEY - TOTAL																		
VALENTINE (1961) [r, N = 151-172]	AIR FORCE OFFICER QUALIFYING TEST:																		
	FLYING INTEREST	.24			.29														
		.07			.10														
	TECHNICAL INTEREST	.25			.25														
		-.03			-.07														
	ADMINISTRATIVE INTEREST	-.04			-.03														
		-.01			-.06														
	QUANTITATIVE INTEREST	.13			.07														
		.00			-.02														

FIGURE 3.4–4 STATISTICAL RESULTS OF FIXED WING PILOT SELECTION STUDIES RELATING MOTIVATIONAL MEASURES TO CRITERIA OF SUCCESS IN TRAINING

CRITERION

PURIFIED PASS–FAIL	TENSION ELIMINATION	TENSION AND AIRSICKNESS ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL – FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP STUDENT–INSTRUCTOR	CRITERION GROUP AVIATION OFFICER CANDIDATE – COLLEGE STUDENT	CRITERION GROUP AVIATION OFFICER CANDIDATE – DROP ON REQUEST	CRITERION GROUP ADJUSTED–MALADJUSTED	CRITERION GROUP AIRCRAFT/PILOT ASSIGNMENT	EXPERIENCE OF MOTION SICKNESS/ AIRSICKNESS	EXPERIENCE OF VERTIGO	GRADES–ACADEMIC	GRADES–FLIGHT	GRADES–MILITARY	GRADES–OVERALL	MILITARY/LEADERSHIP RANK	MOTIVATIONAL MEASURES	STAGE OF ATTRITION	TIME TO SOLO OR COMPLETE TRAINING	TRAINING PHASE
																.09 NS							PRIMARY
																.05 NS .00 NS							PRIMARY INTERMEDIATE
																.01 NS							INTERMEDIATE
																				–.02 NS .03 NS .05 NS			TRAINING
															.00	–.07							PRIMARY BASIC

ERIA OF SUCCESS IN TRAINING

CRITERION

PURIFIED PASS–FAIL	TENSION ELIMINATION	TENSION AND AIRSICKNESS ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL – FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP STUDENT–INSTRUCTOR	CRITERION GROUP AVIATION OFFICER CANDIDATE – COLLEGE STUDENT	CRITERION GROUP AVIATION OFFICER CANDIDATE – DROP ON REQUEST	CRITERION GROUP ADJUSTED–MALADJUSTED	CRITERION GROUP AIRCRAFT/PILOT ASSIGNMENT	EXPERIENCE OF MOTION SICKNESS/ AIRSICKNESS	EXPERIENCE OF VERTIGO	GRADES–ACADEMIC	GRADES–FLIGHT	GRADES–MILITARY	GRADES–OVERALL	MILITARY/LEADERSHIP RANK	MOTIVATIONAL MEASURES	STAGE OF ATTRITION	TIME TO SOLO OR COMPLETE TRAINING	TRAINING PHASE
			5.14*																				TRAINING
																							THROUGH ADVANCED
																			–.05/ .05				TRAINING
																–.12NS/ .21*							FLIGHT
																–17/.42							FLIGHT
			–.05 NS .03 NS .03 NS –.02 NS .15 NS –.12 NS –.18 NS .18 NS .14 NS .02 NS –.01 NS .06 NS –.15 NS .09 NS .12 NS	–.06 NS .00 NS .10 NS –.05 NS .12 NS –.06 NS –.13 NS .13 NS .18* –.09 NS –.01 NS .13 NS –.07 NS .02 NS .03 NS																			FLIGHT
																				6.75**			THROUGH BASIC
.33/.41 .11/.28																							TRAINING
																				.29** .24** .32**			FLIGHT
															.01	–.11							PRIMARY BASIC
															–.02	.08							PRIMARY BASIC
															–.03	.09							PRIMARY BASIC
															–.01	.04							PRIMARY BASIC

CRITERIA OF SUCCESS IN TRAINING

3.4.1.4 Motivation - As shown in Figure 3.4-4, one of the more popular motivational variables has been aviation/flying interest. The relationship between this predictor and success in pilot training is, in some cases, strong.

One of the earliest studies concerned with the effect of motivation on aviation training success was done with an unselected sample of pilot trainees during World War II. Three interest measures were correlated with the pass-fail criterion (trainees were tracked through advanced training). These measures were Strength of Interest: Bombardier, Strength of Interest: Navigator, and Strength of Interest: Pilot. The correlations obtained were low, ranging from -.05 to .09 (DuBois, 1947). Negative findings were also obtained by Greene (1947) and Lane (1947) using the Desire to Fly Inventory. Correlations with flight grades in flight training ranged from -.12 to .21 in the former study and from -.17 to .42 in the latter study, thus showing a great deal of variability.

Aviation/flying interest measures used in later studies show more promising results. In a review of the literature, Sells (1956) reported on two inventories. These are the Aviation Interest Key and the Pilot Opinionaire. Both of these inventories contain items relating to aviation interest. Correlations with the purified pass-fail criterion[13] ranged from .33 to .41 with the Aviation Interest Key and from .11 to .28 with the Pilot Opinionaire. Tupes, et al, (1955) related three attitude survey measures to motivation for flying training. Correlations were .29 with the Military Attitude Survey, .24 with the Flying Attitude Survey, and .32 with the Attitude Survey (total scores). These correlations were significant at the .01 level of confidence. Finally, Valentine (1961) assessed the validity of four Air Force Officer Qualifying Test Interest scores using several criteria (pass-fail and flight failure elimination in primary and basic training, academic and flight grades in basic training). Two interest scores, Administrative Interest and Quantitative Interest, showed little relationship with all criteria (r = -.06 to .09 and -.02 to .13, respectively). Flying Interest scores showed correlations of .24 with the pass-fail criterion and .29 with the flight failure elimination criterion in primary training. Similarly, Technical Interest Scores correlated .25 with both of these criteria in primary training. Both of these interest scores showed low correlations with all criteria in basic training (r = -.11 to .10 and -.17 to .08, respectively).

Another type of interest measure which has been assessed is vocational interest. Using the Kuder Preference Record (KPR), Rosenberg and Izard (1953) found a significant difference between voluntary withdrawal eliminees and successful cadets in five interest areas, and Voas (1959) obtained a significant relationship between the KPR and the pass-fail criterion. However, in the latter study, this relationship was not upheld when mechanical ability differences were controlled.

A second type of motivational variable which has been evaluated is strength of needs. One test which has been used is the Test of Insight which measures the strength of achievement and affiliation drives (French, 1955; French, 1956). French (1956) related these measures to several peer ratings (judgments of achievement motivation, affiliation motivation, friendliness, and goal attainment). Correlations were low in all cases (r = -.05 to .05). Negative findings were also reported by Peterson, Lane, and Kennedy (1965) with the Edwards Personal Preference Schedule (EPPS), a test which assesses the strength of 15 needs. Criteria were flight failure elimination, voluntary withdrawal elimination, and flight failure and voluntary withdrawal elimination combined. Only 2 of 45 correlations reached significance, results well within chance expectations.

In contrast to these studies, Bucky and Burd (1970) used a variant of the need assessment

[13] See Sells' (1956) definition and Section 3.4.

N = SAMPLE SIZE
NS = $p > .05$
* = $p \leq .05$
** = $p \leq .01$

REFERENCE AND STATISTIC	PREDICTOR	CRITERION: PASS-FAIL ATTRITE	ADMINISTRATIVE ELIMINATION	AIRSICKNESS ELIMINATION	FEAR OF FLYING ELIMINATION	FLIGHT FAILURE ELIMINATION	GROUND FAILURE ELIMINATION	MEDICAL ELIMINATION	MOTIVATIONAL ELIMINATION	NOT AERONAUTICALLY ADAPTED ELIMINATION	NOT PHYSICALLY ADAPTED ELIMINATION	PURIFIED PASS-FAIL	TENSION ELIMINATION	TENSION AND AVOIDANCE ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP: STUDENT - INSTRUCTOR	CRITERION GROUP: AVIATION OFFICER CANDIDATE - COLLEGE STUDENT	CRITERION GROUP: AVIATION OFFICER CANDIDATE - DROP ON REQUEST	CRITERION GROUP: ADJUSTED - UNADJUSTED
BUCKY AND RIDLEY (1972) [t, N = 315]	CALIFORNIA PSYCHOLOGICAL INVENTORY:																					
	DOMINANCE																				1.88 NS	
	CAPACITY FOR STATUS																				1.18 NS	
	SOCIABILITY																				1.37 NS	
	SOCIAL PRESENCE																				0.52 NS	
	SELF ACCEPTANCE																				0.34 NS	
	WELL BEING																				0.14 NS	
	RESPONSIBILITY																				0.03 NS	
	SOCIALIZATION																				0.48 NS	
	SELF-CONTROL																				0.01 NS	
	TOLERANCE																				1.30 NS	
	GOOD IMPRESSION																				0.37 NS	
	COMMUNALITY																				2.14*	
	ACHIEVEMENT VIA CONFORMANCE																				0.57 NS	
	ACHIEVEMENT VIA INDEPENDENCE																				0.27 NS	
	INTELLECTUAL EFFICIENCY																				1.35 NS	
	PSYCHOLOGICAL MINDEDNESS																				1.06 NS	
	FLEXIBILITY																				0.27 NS	
	FEMININITY																				1.51 NS	
CULPEPPER, JENNINGS AND PERRY (1972) [r, N = 12-18]	PSYCHOLOGICAL RANKINGS (3 PERSONALITY AND 1 INTELLIGENCE TEST)																					
	PSYCHIATRIC RANKING ON SUITABILITY																					
FLEISCHMAN, AMBLER, PETERSON, AND LANE (1966) [r, N = 575-643]	TAYLOR MANIFEST ANXIETY SCALE	-.10*				.03 NS									-.16**							
	ALTERNATE MANIFEST ANXIETY SCALE	-.01 NS				.04 NS									-.05 NS							
	PENSACOLA Z SCALE	-.02 NS				-.03 NS									-.01 NS							
	ADJECTIVE CHECK LIST	.06 NS				.06 NS									.03 NS							
	CATELL'S 16 PERSONALITY FACTOR QUESTIONNAIRE:																					
	WARM-ALOOF	-.05 NS				-.04 NS									-.04 NS							
	INTELLIGENCE-MENTAL DEFECT	.02 NS				.01 NS									.03 NS							
	MATURE-IMMATURE	.10*				.01 NS									.13**							
	AGRESSIVE-MILD	-.07 NS				-.05 NS									-.06 NS							
	ENTHUSIASTIC-GLUM	.02 NS				.02 NS									.01 NS							
	CONSCIENTIOUS-CASUAL	.02 NS				-.02 NS									.05 NS							
	ADVENTUROUS-SHY	-.02 NS				-.07 NS									.03 NS							
	SENSITIVE-TOUGH	-.08 NS				-.04 NS									-.09*							
	SUSPECTING-ACCEPTING	.00 NS				.02 NS									-.01 NS							
	UNCONVENTIONAL-PRACTICAL	-.02 NS				.00 NS									-.04 NS							
	SOPHISTICATED-SIMPLE	.00 NS				.07 NS									-.05 NS							
	TIMID -- CONFIDENT	-.02 NS				.12**									-.06 NS							
	RADICALIST-CONSERVATIST	-.03 NS				-.04 NS									-.01 NS							
	SELF SUFFICIENT-DEPENDENT	.00 NS				.01 NS									-.00 NS							
	CONTROLLED-LAX	.02 NS				-.02 NS									.04 NS							
	TENSE-COMPOSED	-.00 NS				.08 NS									-.07 NS							
FULKERSON, FREUD, AND RAYNOR (1958) [r, N = 400]	MINNESOTA MULTIPHASIC PERSONALITY INVENTORY:																					
	LIE SCORE																					-.02 NS
	VALIDITY SCORE																					.12**
	CORRECTION SCORE																					-.17**
	HYPOCHONDRIASIS																					.21**
	HYPOCHONDRIASIS PLUS CORRECTION																					.11 NS
	DEPRESSION																					.17**
	HYSTERIA																					.12*
	PSYCHOPATHIC DEVIATE																					.20**
	PSYCHOPATHIC DEVIATE PLUS CORRECTION																					.12*
	MASCULINITY-FEMININITY																					.11 NS
	PARANOIA																					.05 NS
	PSYCHASTHENIA																					.10**
	PSYCHASTHENIA PLUS CORRECTION																					.08 NS
	SCHIZOPHRENIA																					.08 NS
	SCHIZOPHRENIA PLUS CORRECTION																					-.03 NS
	HYPOMANIA																					-.03 NS
	HYPOMANIA PLUS CORRECTION																					-.07 NS
	SOCIAL INTROVERSION																					.12 NS
JESSUP AND JESSUP (1971) [χ^2, N = 167]	EYSENCK PERSONALITY INVENTORY	11.79**																				
MCMICHAEL AND GRAYBIEL (1963) [r, N = 9]	RORSCHACH COMPOSITES: ANXIETY																					
	DEPENDENCY																					
	DRIVE																					
	LABILITY OF EMOTIONS																					
	RIGIDITY																					
	TOTAL																					
TREXLER (1969) [t, N = 1015] [R, N = 1015]	EGO IDENTITY QUESTIONNAIRE	16.26** .19																				
TUCKER AND REINHARDT (1966) [χ^2, N = 40-56]	RORSCHACH TEST - BODY IMAGE BOUNDARIES: BARRIER DIMENSION																					
	PENETRATION DIMENSION																					
VOAS, BAIR, AND AMBLER (1957) [F, N = 248]	TAYLOR MANIFEST ANXIETY SCALE				8.01**																	
	SASLOW SCREENING TEST				4.76**																	
[F, N = 342]	HEINEMAN ANXIETY SCALE				8.04**																	
WILLINGHAM AND AMBLER (1963) [r, N = 208]	GORDON PERSONALITY INVENTORY: CAUTIOUSNESS																					-.15*
	VIGOR																					.13*

FIGURE 3.4–5 STATISTICAL RESULTS OF FIXED WING PILOT SELECTION STUDIES RELATING PERSONALITY MEASURES TO CRITE

DOUGLAS CORPORATION

CRITERION																						
VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL - FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP STUDENT-INSTRUCTOR	CRITERION GROUP AVIATION OFFICER CANDIDATE - COLLEGE STUDENT	CRITERION GROUP AVIATION OFFICER CANDIDATE - DROP ON REQUEST	CRITERION GROUP ADJUSTED-MALADJUSTED	CRITERION GROUP AIRCRAFT/PILOT ASSIGNMENT	EXPERIENCE OF MOTION SICKNESS: AIRSICKNESS	EXPERIENCE OF VERTIGO	GRADES-ACADEMIC	GRADES-FLIGHT	GRADES-MILITARY	GRADES-OVERALL	MILITARY LEADERSHIP RANK	MOTIVATIONAL MEASURES	STAGE OF ATTRITION	TIME TO SOLO OR COMPLETE TRAINING	TRAINING PHASE
						1.88 NS 1.18 NS 1.37 NS 0.52 NS 0.34 NS 0.14 NS 0.02 NS 0.48 NS 0.01 NS 1.30 NS 0.37 NS 2.14*													FLIGHT
						0.57 NS																
						0.27 NS 1.35 NS 1.06 NS 0.27 NS 1.51 NS								.19 NS/ 51** -.19 NS/ 57**						USAF AEROSPACE RESEARCH PILOT SCHOOL
-.16**																				FLIGHT
-.05 NS -.01 NS .03 NS																				
-.04 NS .03 NS .12**																				
-.06 NS .01 NS .05 NS .03 NS -.09*																				
-.07 NS -.04 NS -.05 NS -.06 NS -.01 NS -.00 NS .04 NS -.07 NS																				
							-.02 NS .21** -.17** .22**													TRAINING
							.11 NS .17** .12* .20**													
							.12* .11 NS .05 NS .18**													
							.08 NS .09 NS													
							-.03 NS -.03 NS													
							-.07 NS .12 NS													
									-.12/.38 NS -.16/.05 NS .00 NS .15 NS/ .94** .37 NS/ .78** .47 NS/ .68*										THROUGH BASIC (ROYAL AIR FORCE) EXPERIMENTAL SITUATIONS
											.17/.23									FLIGHT
								NS/4.95* NS/11.78*												PILOT STATUS
																				BASIC
							-.19** -.17*													TRAINING

TING PERSONALITY MEASURES TO CRITERIA OF SUCCESS IN TRAINING

variable and reported positive findings. Voluntary withdrawal eliminees and successful candidates were asked to state how optimistic they were with respect to the program's ability to satisfy their needs. Maslow's five needs were employed (physiological, safety and security, social, self-esteem, and self-actualization). Successful candidates were significantly more optimistic with respect to all needs with the exception of physiological needs. Largest differences appeared with the need for self-actualization[14]. Therefore, it appears that expectations with regard to need satisfaction might be a valuable predictor of voluntary withdrawal elimination.

The prediction of voluntary withdrawal elimination is a problem which has been addressed by a number of studies within the motivational domain. As noted above, "expectations with regard to need satisfaction" seems to be one critical variable (Bucky and Burd, 1970). This is also suggested in a second study. Pomarolli (1966) gave voluntary withdrawal eliminees from basic training a questionnaire containing 57 factors which potentially relate to the decision to withdraw. The most frequent items checked were: (1) losing interest in the program; (2) not deriving satisfaction from the program; and (3) disliking flying. The relationship between aptitude and achievement level is a second factor which was reported to be of value in isolating voluntary withdrawal eliminations. Doll (1971) found higher voluntary withdrawal rates in the high aptitude - low achievement quadrant than in any other quadrant. Factors showing little promise for the prediction of this type of elimination were strength of general needs as assessed by the EPPS (Peterson et al, 1965) and philosophical and religious opinions (Maag and Bair, 1956).

In summary, motivational factors with demonstrated validity for the prediction of success in pilot training are aviation/flying interest, need satisfaction, and the discrepancy between aptitude and achievement levels. The latter two factors seem to be especially important for the isolation of voluntary withdrawal eliminations.

3.4.1.5 Personality - The majority of the studies reviewed in this domain have focused upon the usefulness of personality inventories. These data are summarized in Figure 3.4-5. Ellis and Conrad (1948), in an early review of the literature, summarized the results of personality research related to success in the military (predominantly pass-fail in training). Nineteen studies were cited, covering 16 different personality inventories. They concluded:

> "...only seldom did the personality inventories prove distinctly effective in predicting or discriminating successful from unsuccessful performance." (p. 411)

Studies reviewed in this report are more recent, making use of different personality inventories from those cited by Ellis and Conrad (1948). The outlook for the prediction of success in pilot training is also more positive, perhaps due to advancements in personality test development.

The Minnesota Multiphasic Personality Inventory (MMPI) is one inventory with demonstrated validity in most cases. This instrument contains ten clinical scales, and is the most widely used personality inventory (Anastasi, 1968). Fulkerson, Freud, and Raynor (1958), with a sample of pilots classified as well adjusted or poorly adjusted, found statistically significant correlations with five clinical scales (.20 with Psychopathic Deviate, .18 with Psychasthenia, .12 with Hysteria, .17 with Depression, and .22 with Hypochondriasis).[15] Similarly, Melton (1954), using scores from the MMPI, was able to classify 83% of a sample of Navy cadets into pass-fail categories correctly.

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[14]The stage of training during which this measure is employed may be critical to this finding, since morale level is reported to increase from preflight to basic training (Rickus and Ambler, 1967).

[15]Other self-report inventories found useful for the prediction of psychiatric classifications (e.g., psychiatric casualties) are the Cornell Index (Barry and Raynor, 1953) and the Cornell Word Form (Barry, Sells, and Trites, 1954).

There is some suggestion, however, that the MMPI is differentially effective with different criteria. Voas, Bair, and Ambler (1957) obtained significant differences on seven clinical scales when cadets who failed during preflight training were contrasted with the total population of cadets (all cadets included). However, no differences were obtained between fear of flying eliminees in basic training and the total population.

The Eysenck Personality Inventory (EPI) is a second self-report inventory with demonstrated validity for the prediction of success in training. The EPI measures two personality dimensions: (1) Extroversion-Introversion; and (2) Neuroticism-Stability. With a Royal Air Force sample, Jessup and Jessup (1971) found significant differences using the pass-fail crierion. A relatively large number of failures occurred in the Neurotic-Introvert quadrant (60%) and relatively few in the Stable-Introvert quadrant (14%). Cadets in the two Extrovert quadrants had failure rates of 32 to 37%.

Other personality dimensions found to be related to success in training are ego identity, cautiousness, and vigor. Trexler (1969) developed an Ego Identity Questionnaire measuring three personality aspects: (1) knowledge of who you are; (2) knowledge of where you are going; and (3) awareness of how you are perceived by others. Criteria used were the pass-fail criterion and academic grades in flight training. Significant differences were obtained between pass and fail groups, with lower ego identity scores among failures. Multiple correlations were .19 with the pass-fail criterion, and .17 to .23 with academic grades. Willingham and Ambler (1963) found significant correlations between two traits measured by the Gordon Personality Inventory (GPI) and delinquency reports in training. These correlations were -.19 with the Cautiousness dimension and -.17 with the Vigor dimension.

"The Thousand Aviator Study," a longitudinal study conducted by the Navy and the U.S. Public Health Service, and later by NASA, provides data on the relationship between the psychological characteristics of a large group of aviators and their physical, physiological and life history characteristics (Oberman, Lane, Mitchell, and Graybiel, 1965). This study began in 1940 when 1056 student aviators and flight instructors were examined on a variety of physiological and psychological parameters. Follow-up examinations were conducted in 1951, 1957, and 1963-65; the latter being the most comprehensive to data. In the 1963-65 study, 675 members of the Thousand Aviator Group were evaluated in Pensacola.

Ten of 100 variables studied in "The Thousand Aviator Study" were scales of the Guilford-Zimmerman Temperament Survey (GZTS), a 300 question, self-report personality questionnaire. Figure 3.4-6 summarizes statistically significant[16] correlations between 90 anthropometric, physical, physiological and life history variables and each of the ten GZTS scales. While some 68 of the possible 900 correlations were significant, none was greater than .19. Although it can be argued that the test population was relatively homogeneous, no compelling case can be made for high relatedness between temperament and anthropometric, physical, or physiological characteristics.[17] While this effort was quite ambitious, it has limited usefulness since the question of how these variables relate to success in military training was not addressed.

Other self-report inventories which have been investigated, but which show little promise as predictors, include the California Psychological Inventory (Bucky and Ridley, 1972), the Pensacola Z Scale, the Adjective Check List, and Catell's 16 Personality Factor Questionnaire (Fleishman, et al, 1966).

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[16]The .015 level of confidence was used by the authors to adjust for artifactual significance resulting from multiple comparisons.

[17]Also, see Cook (1961), Cortes and Gatti (1965), and Cortes and Gatti (1966).

G – GENERAL ACTIVITY	O – OBJECTIVITY
R – RESTRAINT	F – FRIENDLINESS
A – ASCENDANCE	T – THOUGHTFULNESS
S – SOCIABILITY	P – PERSONAL RELATIONS
E – EMOTIONAL STABILITY	M – MASCULINITY

9–1124

SCALE

	G	R	A	S	E	O	F	T	P	M
1. AGE										
2. SYSTOLIC BLOOD PRESSURE SUPINE, BASAL				102						
3. DIASTOLIC BLOOD PRESSURE SUPINE, BASAL				104			–130			
4. SYSTOLIC BLOOD PRESSURE SITTING, BASAL				102						
5. DIASTOLIC BLOOD PRESSURE SITTING, BASAL				126			–115			
6. SYSTOLIC BLOOD PRESSURE SUPINE, CASUAL				116			–110			
7. DIASTOLIC BLOOD PRESSURE SUPINE, CASUAL							–148			
8. SYSTOLIC BLOOD PRESSURE SITTING, CASUAL				110			–115			
9. DIASTOLIC BLOOD PRESSURE SITTING, CASUAL							–133			
10. PULSE PRESSURE, SUPINE										
11. PULSE PRESSURE SITTING										
12. ARCUS SENILIS										
13. FUNDUS							–169			
14. HEMATOCRIT										
15. WHITE BLOOD COUNT										
16. PROTEIN–BOUND IODINE										
17. GLUCOSE, FASTING										
18. GLUCOSE, TWO-HOUR POST PRANDIAL				101					108	
19. CHOLESTEROL		–106					–109			
20. CALCULATED CHOLESTEROL		–141		109			–131			
21. CALCULATED TRIGLYCERIDES	107	–157	122	116			–129			
22. URIC ACID		–116								
23. LIPOPROTEIN										
24. LOG LIPOPROTEIN 12–20										
25. LOG LIPOPROTEIN 20–400		–121		102						
26. LOG ATHEROGENIC INDEX		–148	100	124			–117			
27. HEIGHT STANDING										
28. HEIGHT SITTING			112							
29. WEIGHT			119							
30. SKINFOLD ARM	–135				101					
31. SKINFOLD BACK										
32. SKINFOLD CHEST										
33. SKINFOLD ABDOMEN										
34. CHEST CIRCUMFERENCE MID-BREATH										
35. CHEST CIRCUMFERENCE INSPIRATION			101							
36. CHEST CIRCUMFERENCE EXPIRATION										
37. CHEST EXPANSION										
38. ABDOMINAL CIRCUMFERENCE		–101					–112			
39. BICEPS RESTING										
40. BICEPS CONTRACTED										
41. CALF CIRCUMFERENCE										
42. BIACHROMIAL DIAMETER										
43. CHEST BREADTH								110		
44. CHEST ANTERIOR-POSTERIOR DIAMETER			156							
45. BIILIAC DIAMETER			106							

34. CHEST CIRCUMFERENCE MID-BREATH										
35. CHEST CIRCUMFERENCE INSPIRATION			101							
36. CHEST CIRCUMFERENCE EXPIRATION										
37. CHEST EXPANSION										
38. ABDOMINAL CIRCUMFERENCE		−101					−112			
39. BICEPS RESTING										
40. BICEPS CONTRACTED										
41. CALF CIRCUMFERENCE										
42. BIACHROMIAL DIAMETER										
43. CHEST BREADTH								110		
44. CHEST ANTERIOR-POSTERIOR DIAMETER			156							
45. BIILIAC DIAMETER			106							
46. WRIST DIAMETER										
47. ANKLE DIAMETER										
48. PONDERAL INDEX										
49. RELATIVE WEIGHT										
50. BODY FAT										
51. LEAN BODY MASS			106							
52. ENDOMORPHY	−121									
53. MESOMORPHY	149									
54. ECTOMORPHY										
55. DYNAMOMETER										
56. TRANSVERSE DIAMETER OF THE HEART										127
57. DEVIATION FROM PREDICTED TRANSVERSE										145
58. FRONTAL AREA OF HEART										115
59. DEVIATION FROM PREDICTED FRONTAL AREA										
60. CARDIOTHORACIC INDEX										127
61. ELECTROENCEPHALOGRAPHIC INTERPRETATION										
62. VITAL CAPACITY		100								
63. INSPIRATORY CAPACITY										
64. EXPIRATORY RESERVE		109					123			
65. BALLISTOCARDIOGRAM										
66. CORONARY HEART DISEASE										
67. ALCOHOL AMOUNT		−192					−137		−108	
68. SOCIAL STATUS						−109				
69. MILITARY STATUS										
70. CIGARETTE AMOUNT		−193			−113		−101			
71. CIGARETTE YEARS		−183			−115		−149		−120	
72. FLYING YEARS										
73. HEART RATE		−144								
74. HEART RATE IMMEDIATELY AFTER EXERCISE										
75. PR INTERVAL										
76. QRS DURATION										
77. QRS FRONTAL VECTOR										
78. T FRONTAL VECTOR	−101		−108							
79. QRS-T ANGLE FRONTAL PLANE										
80. SIGMA QRS										
81. SIGMA T										
82. MAXIMAL QRS VOLTAGE FRONTAL PLANE										
83. MAXIMAL QRS DEFLECTION FRONTAL PLANE										
84. AMPLITUDE T (1)	103									
85. RATIO T(1)/R (1)							110			
86. AMPLITUDE S (1) + S (11) + S (111)										
87. AMPLITUDE S (V_1) + R (V_5 OR V_6)										
88. MAXIMAL Z AFTER EXERCISE										
89. MAXIMAL J-ST AFTER EXERCISE										
90. MAXIMAL ST AFTER EXERCISE										

*DECIMAL POINTS ARE OMITTED

FIGURE 3.4-6 STATISTICALLY SIGNIFICANT CORRELATIONS BETWEEN THE TEN GZTS SCALES AND THE NINETY OTHER VARIABLES THAT WERE STUDIED IN THE "THOUSAND AVIATOR STUDY"*

There are several self-report inventories which specifically measure differences in anxiety. One of the more well-known is the Taylor Manifest Anxiety Scale (TMAS). Fleischman, et al, (1966) related scores on this inventory as well as on the Alternate Manifest Anxiety Scale (AMAS) to three criteria of success in flight training. These were the pass-fail, flight failure elimination, and voluntary withdrawal elimination criteria. Both tests were administered during the first week of training (preflight). Scores on the TMAS correlated significantly with the pass-fail criterion ($r = -.10$) and the voluntary withdrawal elimination criterion ($r = -.16$). AMAS scores were unrelated to all criteria.

There is some suggestion, however, that the TMAS, when administered early in training, shows differential validity with different criteria. Voas, et al, (1957) obtained significant differences with the TMAS, administered during the first week of primary training, when failures during preflight training were contrasted with the total population of cadets (all cadets included). However, no differences were obtained between fear of flying eliminees in basic training and the total population. When the TMAS was administered at the time of separation from training, significant differences were found between fear of flying eliminees and two other groups (entering cadets and cadets separated from the program and not reporting fear). Therefore, the TMAS showed concurrent validity, but not predictive validity for fear of flying elimination in basic training. A similar pattern of results was obtained with the Heineman Anxiety Scale (HAS). Significant differences were also found between these groups with the Saslow Screening Test, another anxiety test, when administered at the time of separation from the program.

Clinical assessment is a third class of predictor within the domain of personality. These assessments are typically based upon clinical interviews which sometimes include projective tests.

One clinical assessment measure is the Adaptability Rating for Military Aeronautics (ARMA), a personality assessment made by the flight surgeon. In an unselected sample of pilot trainees during World War II, the ARMA showed a correlation of approximately .20 with the pass-fail criterion (DuBois, 1947). However, as noted by Mebane (1957), the relationship between the ARMA and criteria is dependent upon the skill of the examiner. Culpepper, Jennings, and Perry (1972) reported on the validity of psychiatric rankings of suitability for the prediction of class standing in the United States Air Force Research Pilot School. Correlations showed a great deal of variability, ranging from -.19 to .57 with different classes.

One of the more popular projective techniques is the Rorschach Test, which consists of a series of inkblot displays. Responses to these displays are then assessed by clinical personnel. Holtzman and Sells (1954) found these clinical assessments to be ineffective for the prediction of pass-fail in basic flight training.

With other criteria, these assessments have been more useful. McMichael and Graybiel (1963) related scores on five Rorschach composites (anxiety, dependency, drive, lability [instability] of emotions, and rigidity) to ranked scores on susceptibility to airsickness in four experimental situations. These situations consisted of exposure to aerial acrobatics, going to sea in a power boat in a high sea state, exposure in a slow rotation room, and experiencing zero g. These correlations ranged from -.12 to .94. The highest correlations were obtained with the lability and rigidity composites. Correlations with the total composite were significant in three of the four situations ($r = .47$ to $.68$). In addition, Tucker and Reinhardt (1966) found significant relationships between two Rorschach scores and the type of aircraft flown. Scores were obtained for a barrier dimension (degree of body boundary definiteness) and penetration (degree to which body boundary is perceived as permeable). Jet pilots had higher barrier scores than did propellar and

helicopter pilots. This indicates a well-defined body image among jet pilots who have few visual cues for reference while flying. Secondly, helicopter pilots had lower penetration scores than did propellar aircraft pilots, which is interpreted as indicating lower anxiety. However, since this study used pilots rather than pilot candidates, little can be said with respect to the value of these Rorschach composites for selection.

In summary, some personality inventories (MMPI, EPI, Ego Identity Questionnaire, GPI, TMAS, HAS) seem to show some promise for the prediction of success in pilot training. Potential limitations with respect to the prediction of fear of flying eliminations have been noted with several of these inventories, especially those measuring anxiety.

Clinical assessments while related to some criteria (susceptibility to airsickness), appear to be less useful with other criteria (e.g., the pass-fail criterion).

3.4.1.6 Reaction to Stress - As can be seen from Figure 3.4-7, studies reviewed in this domain are of two basic types: (1) those using paper-and-pencil tests; and (2) those using stressful situations. Most studies were predominantly of the former type.

Some of the research using paper-and-pencil tests are studies of concurrent validity rather than predictive validity, making conclusions about selection difficult.[18] Clark and Graybiel (1957) studied the relationship between reactions to high altitude flights reported in an interview and the number of vertigo (confusion with regard to position in space) experiences reported in a Checklist of Flight Experiences. More vertigo experiences were found in pilots reporting increased excitement, fear, anxiety, and increased alertness. However, these data are difficult to interpret. These differences could result from prior differences in the ability to handle stress. Alternatively, they could be the product of differences in vertigo experiences.

This type of problem is present in two additional studies. Roberts and Wicke (1972) found differences in self-testing attitudes among fighter, attack, helicopter, and patrol aircraft pilots. Fighter pilots had higher self-testing attitudes than did all other types of pilots. Finally, Aitken (1972) investigated the reactions of normal and aerophobic pilots to several types of situations in a self-report inventory. Aerophobic pilots reported that they could spend less time seated in four situations (normal sortie, standby, reading, and in the cinema). As with the prior study, no conclusion can be drawn with regard to the value of these measures for selection.

Studies using paper-and-pencil tests which permit interpretation have focused upon anxiety and stress tolerance measures. The State-Trait Anxiety inventory is one instrument which has been assessed (Bucky, Spielberger, and Bale, 1970; Holzapfel, 1973). Bucky, et al, (1970) found greater levels of state anxiety (transitory anxiety) and lower levels of trait anxiety (anxiety proness) in aviation officer candidates than in college students. However, other data question the value of these measures for the prediction of success in flight training. Holzapfel (1973) obtained negative correlations with the criterion of flight grades, but none of these values reached significance.

The Defense Mechanism Test (DMT), a measure of stress tolerance, has demonstrated validity as a secondary selection tool with Swedish pilot candidates (Neuman, 1968; Neuman, 1972). Correlations with the pass-fail criterion in basic training were .35 with an initial sample and .46 with a cross-validation sample. Both values were significant at the .01 level of confidence.

[18] Tests are administered to pilot populations rather than to pilot candidates. Although tests may discriminate between pilot populations, there is no assurance that these same tests will be sensitive to differences between pilot candidates.

N = SAMPLE SIZE
NS = $p > .05$
* = $p \leq .05$
** = $p \leq .01$

REFERENCE AND STATISTIC	PREDICTOR	CRITERION: PASS-FAIL ATTRITE	ADMINISTRATIVE ELIMINATION	AIRSICKNESS ELIMINATION	FEAR OF FLYING ELIMINATION	FLIGHT FAILURE ELIMINATION	GROUND FAILURE ELIMINATION	MEDICAL ELIMINATION	MOTIVATIONAL ELIMINATION	NOT AERONAUTICALLY ADAPTED ELIMINATION	NOT PHYSICALLY ADAPTED ELIMINATION	PURIFIED PASS-FAIL	TENSION ELIMINATION	TENSION AND AIRSICKNESS ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL - FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP STUDENT - INSTRUCTION	CRITERION GROUP AVIATION OFFICER CANDIDATE - COLLEGE STUDENT	CRITERION GROUP AVIATION OFFICER CANDIDATE - DROP ON REQUEST	CRITERION GROUP
AITKEN (1972) [r, N = 107]	REACTIONS TO SITUATIONS: APPREHENSION: DISORIENTATION																					6/1.1 NS
	NORMAL SORTIE																					4/1.0 NS
	EMERGENCY																					7 NS/1.3
	BRIEFING																					2 NS
	PUBLIC SPEAKING																					2 NS
	TENSENESS: DISORIENTATION																					2/.7 NS
	NORMAL SORTIE																					3 NS/1.0
	EMERGENCY																					2 NS/1.0
	DRIVING																					1 NS
	DURATION SEATED TILL DISCONFORT: NORMAL SORTIE																					4.1**/1.0
	STANDBY																					7.8**
	READING																					4.9**
	CINEMA																					5.9**
AMBLER AND GUEDRY (1968) [r, N = 239]	BRIEF VESTIBULAR DISORIENTATION TEST	.14*		.18**									.23**	.23**								
BUCKY, SPIELBERGER AND BALE (1970) [r, N = 387]	MEASURES OF MANIFEST ANXIETY: TRAIT ANXIETY																			.22**		
	STATE ANXIETY																			.43**		
CLARK AND GRAYBIEL (1957) [r, N = 101]	EMOTIONAL REACTIONS DURING HIGH ALTITUDE FLIGHTS: INCREASED EXCITEMENT																					
	INCREASED EXHILERATION																					
	FEAR																					
	ANXIETY																					
	INCREASED ALERTNESS																					
	DESIRE TO GO LOWER																					
NEUMAN (1968) [r, N = 87-116]	DEFENSE MECHANISM TEST	.35/.46**																				
VOAS, BAIR, AND AMBLER (1956) *, N = 1366]	REACTIONS TO DECOMPRESSION CHAMBER				2.91**																	

FIGURE 3.4-7 STATISTICAL RESULTS OF FIXED WING PILOT SELECTION STUDIES RELATING MEASURES OF REACTION TO STRESS TO CRITERIA OF SUCCESS IN TRAINING

N = SAMPLE SIZE
NS = $p > .05$
** = $p \leq .01$

REFERENCE AND STATISTIC	PREDICTOR	CRITERION: PASS-FAIL ATTRITE	ADMINISTRATIVE ELIMINATION	AIRSICKNESS ELIMINATION	FEAR OF FLYING ELIMINATION	FLIGHT FAILURE ELIMINATION	GROUND FAILURE ELIMINATION	MEDICAL ELIMINATION	MOTIVATIONAL ELIMINATION	NOT AERONAUTICALLY ADAPTED ELIMINATION	NOT PHYSICALLY ADAPTED ELIMINATION	PURIFIED PASS-FAIL	TENSION ELIMINATION	TENSION AND AIRSICKNESS ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL - FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP STUDENT - INSTRUCTION	CRITERION GROUP AVIATION OFFICER CANDIDATE - COLLEGE STUDENT	CRITERION GROUP AVIATION OFFICER CANDIDATE - DROP ON REQUEST	CRITERION GROUP
FLEISCHMAN, AMBLER, PETERSON, AND LANE (1966) [r, N = 700]	PEER RATINGS	.17**				.23**									.06 NS							
MARTOCCIA AND NELSON (1956) [r, N = 353]	INSTRUCTOR'S OPINION REGARDING SUCCESS: PRE SOLO FLIGHT 11	.26**																				
[r, N = 455]	PRE SOLO FLIGHT 18	.30**																				
[r, N = 372]	PRECISION FLIGHT 16	.33**																				
SUCI AND VALLANCE (1954) [r, N = 129-138]	PEER RATINGS: PROMISE AS FUTURE OFFICER																					
	OUTSTANDINGNESS AS OFFICER CANDIDATE																					
	STUDENT APTITUDE																					
TUPES, BOWLES, AND TORR (1955) [r, N = 212]	PEER RATINGS																					
WAAG AND SHANNON (1972) [r, N = 1330]	INSTRUCTOR RATINGS: PROBABILITY OF GETTING WINGS	.28																				
	MOTIVATION	.20																				
	HEADWORK	.23																				
	REACTION TO STRESS	.25																				
WILLINGHAM (1958) [r, N = 472-522]	PEER NOMINATIONS ON 17 TRAITS					-.10/.35									-.13/.32							

FIGURE 3.4-8 STATISTICAL RESULTS OF FIXED WING PILOT SELECTION STUDIES RELATING SOCIAL MEASURES TO CRITERIA OF SUCCESS IN TRAINING

NNELL DOUGLAS
CORPORATION

2

TERION AND AIRSICKNESS ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL - FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP STUDENT-INSTRUCTOR	CRITERION GROUP AVIATION OFFICER CANDIDATE - COLLEGE STUDENT	CRITERION GROUP AVIATION OFFICER CANDIDATE - DROP ON REQUEST	CRITERION GROUP ADJUSTED-MALADJUSTED	CRITERION GROUP AIRCRAFT-PILOT ASSIGNMENT	EXPERIENCE OF MOTION SICKNESS/ AIRSICKNESS	EXPERIENCE OF VERTIGO	GRADES-ACADEMIC	GRADES-FLIGHT	GRADES-MILITARY	GRADES-OVERALL	MILITARY LEADERSHIP RANK	MOTIVATIONAL MEASURES	STAGE OF ATTRITION	TIME TO SOLO OR COMPLETE TRAINING	TRAINING PHASE
CRITERION																						
								6/1.1 NS 4/1.0 NS 7 NS/1.7* 2 NS 2 NS 2/.7 NS 3 NS/2.2* 2 NS/1.8* 1 NS 4.1**/5.4** 7.8** 4.9** 5.9**													PILOT STATUS
						3.23** 9.43**																TRAINING
											1 NS 1 NS											TRAINING
																						PILOT STATUS
																						BASIC (SWEDISH)
																						BASIC

F SUCCESS IN TRAINING

TERION AND AIRSICKNESS ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL - FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP STUDENT-INSTRUCTOR	CRITERION GROUP AVIATION OFFICER CANDIDATE - COLLEGE STUDENT	CRITERION GROUP AVIATION OFFICER CANDIDATE - DROP ON REQUEST	CRITERION GROUP ADJUSTED-MALADJUSTED	CRITERION GROUP AIRCRAFT-PILOT ASSIGNMENT	EXPERIENCE OF MOTION SICKNESS/ AIRSICKNESS	EXPERIENCE OF VERTIGO	GRADES-ACADEMIC	GRADES-FLIGHT	GRADES-MILITARY	GRADES-OVERALL	MILITARY LEADERSHIP RANK	MOTIVATIONAL MEASURES	STAGE OF ATTRITION	TIME TO SOLO OR COMPLETE TRAINING	TRAINING PHASE
CRITERION																						
	06 NS																					FLIGHT
																						BASIC
												24/.34 38/.62 41/.44		33/.73 35/.71 47/.70							TRAINING
																		06 NS				FLIGHT
																						FLIGHT
	~13/.32																			~21/.12		FLIGHT

NING

Encouraging findings were reported in studies using stress tests as predictors. One such test is the Brief Vestibular Disorientation Test, in which reactions to a rotating chair are assessed (Ambler and Guedry, 1965; Ambler and Guedry, 1968). Measures consisted of overall ratings by observers after rotation had stopped. These ratings were based upon factors such as pallor, sweating, facial expression, and unsteadiness. In one study, correlations were .14 with the pass-fail criterion, .23 with the tension elimination criterion, .18 with the airsickness elimination criterion, and .23 with the tension or airsickness elimination criterion (Ambler and Guedry, 1968). All correlations were significant at the .05 level of confidence or better. Similar relationships were reported in an earlier study (Ambler and Guedry, 1965).

Voas, Bair, and Ambler (1956) assessed the validity of reactions in a decompression chamber. Measures were replacement of the oxygen mask before the end of a ten minute test period and reports of ear block. These responses were interpreted as indicative of anxiety. Significant differences were found between fear of flying eliminees and successful candidates in basic training, with greater anxiety in the former group.

In summary, with the exception of the DMT, a foreign selection instrument, evidence for the validity of paper-and-pencil tests in this domain is lacking. In contrast, performance measures in realistic, stressful situations, such as exposure to rotation and decompression, appear to be valid predictors of success in pilot training.[19]

3.4.1.7 Social - Peer and instructor ratings constitute a valuable set of predictors for success in training. With a few exceptions, relationships found with these ratings were relatively substantial (see Figure 3.4-8).

Studies on peer ratings differ with respect to the specificity of the rating used, i.e., overall ratings versus individual ratings on specific traits. Overall ratings were employed in two studies reviewed. Fleischman, et al, (1966) found significant correlations between preflight peer ratings and two of three criteria investigated (r = .17 with the pass-fail criterion, r = .23 with the flight failure elimination criterion). The voluntary withdrawal elimination criterion was not predictable from this rating (r = .06). A second prediction failure was reported by Tupes, et al, (1966). No relationship was found between peer ratings from the ROTC Evaluation Scale and motivation for flying training.

Other studies have focused upon the validity of more specific types of peer ratings. There is little overlap with respect to the types of ratings investigated in this research. Suci and Valance (1954) related three types of ratings (Promise as an Officer, Outstandingness as an Officer, and Aptitude) to military and academic grades in Naval Officer Candidate School. All three ratings proved useful. Ratings on Promise as an Officer showed correlations of .33 to .73 with military grades and .24 to .34 with academic grades. Similar results were reported with the other two types of ratings.

Willingham (1958) studied the relationship between peer ratings on 17 personal traits[20] and three criteria: (1) Flight failure elimination; (2) Voluntary withdrawal elimination; and (3) Number of months required to complete flight training. The ranges of these correlations are

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[19] Studies also indicate that physiological measures in stressful situations have potential value for selection in training (Mefferd, Hale, Shannon, Prigmore, and Ellis, 1971; O'Connor, 1973).

[20] Several studies have addressed the question of the factor structure of peer ratings on personal traits. With different samples of basic airmen, Elliott (1960) and Ewart (1960) found four interpretable factors. These were: (1) General Factor (overall acceptance or rejection factor), (2) Good Naturedness, (3) Sociability, and (4) Motivation for Military Life. Tupes and Kaplan (1961a) obtained five factors with a sample of Air Force Officers: (1) Surgency (quickness and cleverness), (2) Agreeableness, (3) Determination, (4) Adjustment, and (5) Social Intelligence.

shown in Figure 3.4-8. The Leadership Rating was the best predictor of the flight failure elimination criterion (r = .27 to .29) and number of months to complete flight training (r = .18). The voluntary withdrawal elimination criterion was predicted equally well by the Leadership Rating (r = .20 to .21) and the rating for the question: ". . . this person would never consider DORing"[21] (p. 5) (r = .27 to .28). Finally, Peterson, Lane, and Ambler (1966) found significant correlations between carefulness peer ratings and two criteria (preflight grades and the pass-fail criterion).

Comparable results have been obtained with instructor ratings. The Instructor Prediction Form is one questionnaire that has been used (Martoccia and Nelson, 1956). In this questionnaire, instructors are asked their opinion regarding each candidate's probability of completing a specific flight phase. Correlations with the pass-fail criterion in basic training ranged from .26 to .36. Waag and Shannon (1972) investigated the relationship between four instructor ratings (Probability of Getting Wings, Motivation, Headwork, and Reaction to Stress) and the pass-fail criterion in flight training. These correlations ranged from .20 to .28. Similar findings were reported by Waag, Shannon, and Ambler (1973) with two samples (Aviation Officer Candidates, and Officers under Instruction).

In conclusion, both peer ratings and instructor ratings seem to be valid predictors of success in pilot training.

3.4.2 Critical Skills - Included in this category are factors related to aviator skills, knowledges, and tasks; information processing rate; job sample performance; light plane performance; sensory-motor skills; and behavior in situational tests. Relationships between these predictors and the criteria noted earlier (Section 3.4) are reviewed in Sections 3.4.2.1 through 3.4.2.6.

3.4.2.1 Aviator Skills, Knowledges, and Tasks - As shown in Figure 3.4-9, predictors within this domain are paper-and-pencil measures as well as flight performance measures.

Many of the paper-and-pencil tests are components of larger classification or aptitude batteries. Two such batteries are the Army Air Force's Qualifying Examination (AAFQE) and the Aircrew Classification Battery (ACB), which were in use during World War II (DuBois, 1947; Flanagan, 1948; Miller, 1947). The AAFQE contained a Flying Information Test. This test showed a correlation of .34 with the pass-fail criterion with an unselected sample of candidates for pilot training during World War II (DuBois, 1947). Three subtests of the ACB showed similarly high correlations with this sample (r = .40 for Dial and Table Reading, r = .37 for Instrument Comprehension I, r = .46 for Instrument Comprehension II).

The Air Force Officer Qualifying Test (AFOQT) includes five subtests which fall within this domain. These are Table Reading, Aerial Landmarks, Instrument Comprehension, Aerial Orientation, and *Visualization of Maneuvers* (Valentine, 1961). Correlations between these subtests and the pass-fail criterion in primary and basic training ranged from -.02 to .45. With the flight failure elimination criterion, these correlations ranged from .11 to .46. Generally, correlations were higher with the latter criterion than with the former. Subtests with the highest validity coefficients were Instrument Comprehension, Aerial Orientation, and Visualization of Maneuvers. With other criteria in basic training, relationships were lower (r = .04 to .19 with academic grades, r = -.06 to .00 with flight grades).

Included in the Army Fixed Wing Aptitude Battery (AFWAB) are tests for Aeronautical Information, Aircraft Orientation, and Flight Visualization (Kaplan, 1965). Correlations between these subtests and the pass-fail criterion in flight training ranged from .20 to .34. With the flight-failure

[21] DORing refers to dropping on request.

N = SAMPLE SIZE
NS = $p > .05$
* = $p \leq .05$
** = $p \leq .01$

REFERENCE AND STATISTIC	PREDICTOR	CRITERION: PASS-FAIL ATTRITE	ADMINISTRATIVE ELIMINATION	AIRSICKNESS ELIMINATION	FEAR OF FLYING ELIMINATION	FLIGHT FAILURE ELIMINATION	GROUND FAILURE ELIMINATION	MEDICAL ELIMINATION	MOTIVATIONAL ELIMINATION	NOT AERONAUTICALLY ADAPTED ELIMINATION	NOT PHYSICALLY ADAPTED ELIMINATION	PURIFIED PASS-FAIL	TENSION ELIMINATION	TENSION AND AIRSICKNESS ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP STUDENT - INSTRUCTOR	CRITERION GROUP AVIATION OFFICER CANDIDATE - COLLEGE STUDENT	CRITERION GROUP AVIATION OFFICER CANDIDATE - DROP ON REQUEST	CRITERION GROUP ADJUSTED - MALADJUSTED
COOPER, IMAYE, KARRE, ROBERTSON, RYAN AND SAKAHARA (1976) [r, N = 33]	UNDERGRADUATE PILOT TRAINING FLYING GRADES																					
DUBOIS (1947) [r, N = 1137]	AIRCREW CLASSIFICATION BATTERY:																					
	DIAL AND TABLE READING	.40																				
	INSTRUMENT COMPREHENSION I	.37																				
	INSTRUMENT COMPREHENSION II	.46																				
	ARMY AIR FORCE QUALI FYING EXAM: FLYING INFORMATION	.34																				
FLYER AND BIGBEE (1955b) [r, N = 238-269]	PRIMARY FLYING GRADES: INSTRUMENT FLYING GRADE	.35**				.47**																
	ACROBATIC FLYING GRADE	.11 NS				.33**																
	PRIMARY FLYING GRADE	.37**				.60**																
GREENE (1947) [r, N = 88]	AVIATION INFORMATION TEST																					
KAPLAN (1965) [r, N = 740-1245]	ARMY FIXED WING APTITUDE BATTERY:																					
	AERONAUTICAL INFORMATION	.20/.34				.46																
	AIRCRAFT ORIENTATION	.23/.28				.18																
	FLIGHT VISUALIZATION	.24/.30				.23																
LANE (1947) [r, N = 37]	AVIATION INFORMATION TEST																					
MARTOCCIA AND NELSON (1956) [r, N = 482]	INSTRUCTOR GRADE PRE SOLO FLIGHT #18	.17**																				
TUPES, BOWLES, AND TORR (1955) [r, N = 206]	AVIATION CADET – OFFICER CANDIDATE QUALIFYING TEST: AERIAL ORIENTATION																					
VALENTINE (1961) [r, N = 151-172]	AIR FORCE OFFICER QUALIFYING TEST: TABLE READING	-.02				.11																
		.07				.15																
	AERIAL LANDMARKS	.14				.25																
		.20				.23																
	INSTRUMENT COMPREHENSION	.29				.46																
		.21				.44																
	AERIAL ORIENTATION	.28				.38																
		.30				.42																
	VISUALIZATION OF MANEUVERS	.45				.41																
		.27				.31																

FIGURE 3.4-9 STATISTICAL RESULTS OF FIXED WING PILOT SELECTION STUDIES RELATING MEASURES OF AVIATOR SKILLS, KNOWLEDGES, AND TASKS TO CRITERIA OF SUCCESS IN TRAINING

N = SAMPLE SIZE
NS = $p > .05$
* = $p \leq .05$
** = $p \leq .01$

REFERENCE AND STATISTIC	PREDICTOR	CRITERION: PASS-FAIL ATTRITE	ADMINISTRATIVE ELIMINATION	AIRSICKNESS ELIMINATION	FEAR OF FLYING ELIMINATION	FLIGHT FAILURE ELIMINATION	GROUND FAILURE ELIMINATION	MEDICAL ELIMINATION	MOTIVATIONAL ELIMINATION	NOT AERONAUTICALLY ADAPTED ELIMINATION	NOT PHYSICALLY ADAPTED ELIMINATION	PURIFIED PASS-FAIL	TENSION ELIMINATION	TENSION AND AIRSICKNESS ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP STUDENT - INSTRUCTOR	CRITERION GROUP AVIATION OFFICER CANDIDATE - COLLEGE STUDENT	CRITERION GROUP AVIATION OFFICER CANDIDATE - DROP ON REQUEST	CRITERION GROUP ADJUSTED - MALADJUSTED
DAMOS (1972) [r, N = 33]	DIVIDED ATTENTION																					
GOPHER AND KAHNEMAN (1971) [r, N = 100]	SELECTIVE ATTENTION DICHOTIC LISTENING TEST: PART 1: OMISSION ERRORS	.26**																				
	INTRUSION ERRORS	.10 NS																				
	PART 2 TOTAL ERRORS	.36**																				
[r, N = 95]	PART 1: OMISSION ERRORS																					
	INTRUSION ERRORS																					
	PART 2: TOTAL ERRORS																					
NORTH AND GOPHER (1976) [r, N = 43]	DIVIDED ATTENTION																		.55NS/.29**			

–10 STATISTICAL RESULTS OF FIXED WING PILOT SELECTION STUDIES RELATING MEASURES OF INFORMATION PROCESSING RATE TO CRITERIA OF SUCCESS IN TRAINING

2

CRITERION																				
PREDICTOR AND ANTECEDENTS ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP STUDENT - INSTRUCTOR	CRITERION GROUP AVIATION OFFICER CANDIDATE - COLLEGE STUDENT	CRITERION GROUP AVIATION OFFICER CANDIDATE - DROP ON REQUEST	CRITERION GROUP ADJUSTED - MALADJUSTED	CRITERION GROUP AIRCRAFT-PILOT ASSIGNMENT	EXPERIENCE OF MOTION SICKNESS/ AIRSICKNESS	EXPERIENCE OF VERTIGO	GRADES - ACADEMIC	GRADES - FLIGHT	GRADES - MILITARY	GRADES - OVERALL	MILITARY LEADERSHIP RANK	MOTIVATIONAL MEASURES	STAGE OF ATTRITION	TIME TO SOLO OR COMPLETE TRAINING	TRAINING PHASE
													42								REPLACEMENT TRAINING UNIT
																					THROUGH ADVANCED
																					BASIC
													.03 NS/.34**								FLIGHT
																					FLIGHT
													-.36/.35								FLIGHT
																					BASIC
																		-.01 NS			FLIGHT
												.19	-.01								PRIMARY BASIC
												.13	.00								PRIMARY BASIC
												.17	-.06								PRIMARY BASIC
												.04	-.03								PRIMARY BASIC
												.19	-.04								PRIMARY BASIC

TASKS TO CRITERIA OF SUCCESS IN TRAINING

CRITERION																				
PREDICTOR AND ANTECEDENTS ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP STUDENT - INSTRUCTOR	CRITERION GROUP AVIATION OFFICER CANDIDATE - COLLEGE STUDENT	CRITERION GROUP AVIATION OFFICER CANDIDATE - DROP ON REQUEST	CRITERION GROUP ADJUSTED - MALADJUSTED	CRITERION GROUP AIRCRAFT-PILOT ASSIGNMENT	EXPERIENCE OF MOTION SICKNESS/ AIRSICKNESS	EXPERIENCE OF VERTIGO	GRADES - ACADEMIC	GRADES - FLIGHT	GRADES - MILITARY	GRADES - OVERALL	MILITARY LEADERSHIP RANK	MOTIVATIONAL MEASURES	STAGE OF ATTRITION	TIME TO SOLO OR COMPLETE TRAINING	TRAINING PHASE
													17/.69								FLIGHT (PRIVATE PILOT COURSE)
																					THROUGH ADVANCED (ISRAELI AIR FORCE)
																					FLIGHT TR. (ISRAELI AIR FORCE)
					.55NS/ 2.94**				21* .08 NS 32**												TRAINING

CRITERIA OF SUCCESS IN TRAINING

elimination criterion, these correlations ranged from .18 to .46. The Aeronautical Information Test yielded the highest validity coefficients with both criteria.

Tests with little predictive validity were the Aerial Orientation Test, a subtest of the Aviation Cadet-Officer Candidate Qualifying Exam (Tupes, et al, 1955), and the Aviation Information Test (Greene, 1947; Lane, 1947).

As might be expected, flight grades have shown fairly strong relationships with success in training (Cooper, et al, 1976; Flyer and Bigbee, 1955b; Martoccia and Nelson, 1956). For example, Cooper, et al, (1976) obtained a correlation of .42 between undergraduate pilot training flight grades and flight grades in the Replacement Training Unit. Similarly, Flyer, and Bigbee (1955b), reporting on the validity of three primary flight grades, found correlations ranging from .11 to .37 with the pass-fail criterion and from .33 to .60 with the flight-failure elimination criterion in basic training. Five of six correlations were significant at the .01 level of confidence.

In summary, several aptitude/classification batteries contain subtests which seem to be useful in predicting success in pilot training. These include the Flying Information subtest of the AAFQE; Dial and Table Reading and Instrument Comprehension Subtests of the ACB; Instrument Comprehension, Aerial Orientation, and Visualization of Maneuvers subtests of the AFOQT; and the Aeronautical Information subtest of the AFWAB. As anticipated, flight grades also show strong relationships with criteria of success in training.

3.4.2.2 Information Processing Rate - In contrast to many other domains, interest in information processing rate as related to success in pilot training is relatively recent. Available data summarized in Figure 3.4-10 suggest that this area warrants continued attention.

In commenting upon the psychological qualities which are essential to aviators, Lin (1969) listed the following: (1) ability to judge perceptions quickly and accurately; (2) ability to distribute and shift attention; (3) alertness of response; (4) good simulation ability and memory; (5) coordination of hand and foot movements; and (6) stable emotions and strong will. Most of these qualities are in the realm of information processing rate.

Interest in this domain was also expressed by Pew and Adams (1975). They proposed an information processing battery which contains tests in the following areas: (1) active memory capacity; (2) spatial orientation and processing of spatially disparate sources of information; (3) manageability of attention; (4) linguistic decoding; (5) perceptual-motor coordination; and (6) multiple task management and workload capacity. This battery is presently being validated using two measures (pilot ratings and scores on a simulator) collected during the T-37 phase of pilot training.

Two types of tasks were employed in validation studies reviewed: (1) divided attention; and (2) selective attention. Both types of tasks proved useful in selection for pilot training.

In divided attention tasks, two tasks are performed concurrently, and measures of residual attention are monitored. Residual attention refers to the amount of attention left over while performing Task 1 (Primary Task), within certain predefined limits, for the performance of Task 2 (Secondary Task). With a sample of candidates enrolled in a Private Pilot Course, Damos (1972) found substantial correlations between Secondary Task Performance and flight check grades in training. The Primary Task was a compensatory tracking task, while the Secondary Task was an information processing task. Groups were tested before flight training or after 25 hours of flight training, with checkrides conducted after 10, 20, and 30 hours of flight training. Correlations between median response time on the Secondary Task and flight check grades ranged from .17 to .69. Approximately half of these correlations were above .50. Similarly, Trankell (In North and Gopher, 1976) reported a correlation of .42 between scores on a

divided attention task (rhythmic tapping while solving a complex problem) and success in airline pilot training.

North and Gopher (1976) used a somewhat different paradigm for divided attention. Performance on two tasks (compensatory tracking and digit processing tasks) was to be kept within specified limits. Initially, these tasks were performed singly, after which they were performed concurrently. Comparisons were made between students and instructors using measures on both tasks. The most meaningful type of measure was the proportion score, defined as the proportional amount of performance in the single task retained during the dual task or timesharing situation. No differences in proportion scores were found with the digit-processing task. However, instructors had significantly higher proportion scores in the compensatory tracking task, indicating greater timesharing ability among instructors.

Selective attention tasks require screening or attending to relevant information embedded within the context of irrelevant information. One type of selective attention task is dichotic listening, in which candidates are instructed to attend to messages presented to one ear (relevant ear) while messages are also presented to the second ear (irrelevant ear). With an Israeli Air Force sample, Gopher and Kahneman (1971) found correlations ranging from .10 to .36 when selective attention errors were correlated with the pass-fail criterion (candidates were tracked through advanced training). Two of three correlations were significant at the .01 level of confidence. Similar relationships were obtained between these measures and type of pilot assignment (r = .08 to .32).

In conclusion, these data suggest that information processing measures in tasks such as divided attention and selective attention are valid predictors of success in pilot training.

3.4.2.3 Job Sample - In the job sample approach, predictors consist of work samples on trainers which are gathered early in training. It is superior to ability testing in that it allows for the complex interactions of abilities (Goebel, Baum, and Hagin, 1971; Passey and McLaurin, 1966). As can be seen from Figure 3.4-11, this approach appears to be valuable for the prediction of flying proficiency.

Goebel, et al, (1971) related instructor evaluations based upon maneuvers in a General Aviation Trainer (GAT-1) to flight grades at two stages (T-41 and T-37) of training. Correlations with flight grades at the T-41 phase ranged from .44 to .56. All values were significant at the .01 level of confidence. Correlations with flight grades at the T-37 phase were substantially lower (r = .07 to .45), and only 1 of 12 values reached significance. Poorer prediction at this latter stage could be due to a restriction of range produced by the intervening T-41 phase of training.[22]

LeMaster and Gray (1974) studied the relationship between work samples on the T-40 Instrument Trainer and two criteria (T-37 flight grades and the pass-fail criterion in training). Three categories of predictors were used. There were 15 maneuver measures, 6 systems management measures, and 9 flying procedure measures. Scores for maneuvers consisted of deviations from 0 (perfection) on flight parameters such as airspeed, bank, heading, and roll rate. Measures of system management were response times to complete lightbox problems presented while flying the trainer. Flying procedure measures consisted of percentage correct for activities such as power setting, takeoff procedures, turns to assigned headings, and radio communications.

Correlations between maneuver measures (deviations from perfection) and T-37 flight grades (checkrides, instrument check, and phase grade) ranged from -.61 to -.02 (35 of 45 values were statistically significant at the .05 level of

[22]Restriction of range produces a depression in the correlation coefficient (McNemar, 1969).

N = SAMPLE SIZE
NS = $p > .05$
* = $p \leq .05$
** = $p \leq .01$

REFERENCE AND STATISTIC	PREDICTOR	CRITERION: PASS-FAIL ATTRITE	ADMINISTRATIVE ELIMINATION	AIRSICKNESS ELIMINATION	FEAR OF FLYING ELIMINATION	FLIGHT FAILURE ELIMINATION	GROUND FAILURE ELIMINATION	MEDICAL ELIMINATION	MOTIVATIONAL ELIMINATION	NOT AERONAUTICALLY ADAPTED ELIMINATION	NOT PHYSICALLY ADAPTED ELIMINATION	PURIFIED PASS-FAIL	TENSION ELIMINATION	TENSION AND AIRSICKNESS ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL - FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP
GOEBEL, BAUM, AND HAGIN (1971) [r, N = 33-40] [r, N = 24-35]	GENERAL AVIATION TRAINER - 1 GRADES																		
LEMASTER AND GRAY (1974) [r, N = 71]	T-40 INSTRUMENT TRAINER GRADES: MANEUVERS: ERRORS																		
	SYSTEMS MANAGEMENT: LATENCY																		
	FLYING PROCEDURES: PERCENT CORRECT																		
[r, N = 128]	MANEUVERS: ERRORS	-.24**/ -.06 NS																	
	SYSTEMS MANAGEMENT: LATENCY	-.13/ -.02 NS																	
	FLYING PROCEDURES: PERCENT CORRECT	.02 NS/ .19*																	
POE AND LYON (1952) [χ^2, N = 147-156]	CYCLORAMIC LINK TRAINER					.17 NS												.27 NS	

FIGURE 3.4-11 STATISTICAL RESULTS OF FIXED WING PILOT SELECTION STUDIES RELATING MEASURES OF PERFORMANCE ON JOB SAMPLES TO CRITERIA OF SUCCESS IN TRAINING

N = SAMPLE SIZE
NS = $p > .05$
* = $p \leq .05$
** = $p \leq .01$

REFERENCE AND STATISTIC	PREDICTOR	CRITERION: PASS-FAIL ATTRITE	ADMINISTRATIVE ELIMINATION	AIRSICKNESS ELIMINATION	FEAR OF FLYING ELIMINATION	FLIGHT FAILURE ELIMINATION	GROUND FAILURE ELIMINATION	MEDICAL ELIMINATION	MOTIVATIONAL ELIMINATION	NOT AERONAUTICALLY ADAPTED ELIMINATION	NOT PHYSICALLY ADAPTED ELIMINATION	PURIFIED PASS-FAIL	TENSION ELIMINATION	TENSION AND AIRSICKNESS ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL - FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP
BERKSHIRE AND AMBLER (1963)	INSTRUCTOR'S PREDICTION FORM	.36				.28	.14								.30				
[r, N = 196]	FLIGHT GRADES	.34				.38	.16								.13				
FLYER AND BIGBEE (1955a)	INSTUCTOR RATINGS	.29*																	
[r, N = 130]	CHECK PILOT RATINGS	.48*																	
	COMPOSITE INSTRUCTOR AND CHECK PILOT RATINGS	.44**																	
FLYER AND BIGBEE (1955b) [r, N = 238-269]	LIGHT PLANE GRADE	.41**				.54**													
GOEBEL, BAUM, AND HAGIN (1971) [r, N = 24-49]	T-41 GRADES																		
MULLINS AND COX (1960)	FLIGHT INSTRUCTION PROGRAM																		
[t, N = 754]		0.14 NS							0.56 NS										
[t, N = 684]		4.86**				6.15**			2.26*										
[t, N = 514]		2.01*				1.55 NS													

FIGURE 3.4-12 STATISTICAL RESULTS OF FIXED WING PILOT SELECTION STUDIES RELATING MEASURES OF PERFORMANCE ON LIGHT PLANES TO CRITERIA OF SUCCESS IN TRAINING

DONNELL DOUGLAS CORPORATION

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	CRITERION																							
	PURIFIED PASS-FAIL	TENSION ELIMINATION	TENSION AND AIRSICKNESS ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL - FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP STUDENT--INSTRUCTION	CRITERION GROUP AVIATION OFFICER CANDIDATE - COLLEGE STUDENT	CRITERION GROUP AVIATION OFFICER CANDIDATE - DROP ON REQUEST	CRITERION GROUP ADJUSTED--MALADJUSTED	CRITERION GROUP AIRCRAFT/PILOT ASSIGNMENT	EXPERIENCE OF MOTION SICKNESS/ AIRSICKNESS	EXPERIENCE OF VERTIGO	GRADES--ACADEMIC	GRADES--FLIGHT	GRADES--MILITARY	GRADES--OVERALL	MILITARY/LEADERSHIP RANK	MOTIVATIONAL MEASURES	STAGE OF ATTRITION	TIME TO SOLO OR COMPLETE TRAINING	TRAINING PHASE
																44/.56 07NS/.48**							T-41 T-37
																-.61**-.02NS							T-37
																-.35**.01 NS							
																-.10 NS/41**							TRAINING
							27 NS															.004 NS	PRIMARY

E ON JOB SAMPLES TO CRITERIA OF SUCCESS IN TRAINING

	CRITERION																							
	PURIFIED PASS-FAIL	TENSION ELIMINATION	TENSION AND AIRSICKNESS ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL - FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP STUDENT--INSTRUCTION	CRITERION GROUP AVIATION OFFICER CANDIDATE - COLLEGE STUDENT	CRITERION GROUP AVIATION OFFICER CANDIDATE - DROP ON REQUEST	CRITERION GROUP ADJUSTED--MALADJUSTED	CRITERION GROUP AIRCRAFT/PILOT ASSIGNMENT	EXPERIENCE OF MOTION SICKNESS/ AIRSICKNESS	EXPERIENCE OF VERTIGO	GRADES--ACADEMIC	GRADES--FLIGHT	GRADES--MILITARY	GRADES--OVERALL	MILITARY/LEADERSHIP RANK	MOTIVATIONAL MEASURES	STAGE OF ATTRITION	TIME TO SOLO OR COMPLETE TRAINING	TRAINING PHASE
				.30 .13											.23 .22	.49 .54		.37 .36					TRAINING
																							PRIMARY THROUGH BASIC
																							BASIC
																-.10 NS/ 52**							T-37
																							PREFLIGHT PRIMARY BASIC

E ON LIGHT PLANES TO CRITERIA OF SUCCESS IN TRAINING

confidence or better). Correlations between system management measures (latency) and flight grades ranged from -.35 to .01 (7 of 18 values were statistically significant). Correlations between flying procedure measures (percentage correct) and flight grades ranged from -.10 to .41 (8 of 27 values were statistically significant). Therefore, maneuver measures provided the highest validities.

In contrast, correlations with the pass-fail criterion were substantially lower. These correlations ranged from -.24 to .06 with maneuver measures (9 of 15 values reached significance), from -.13 to -.02 with systems management measures (of 6 values, 0 were significant), and from -.02 to .19 with flying procedure measures (3 of 9 values reached significance).

Finally, Poe and Lyon (1952) addressed the question of whether or not instruction in the Cycloramic Link Trainer increased the probability of success in primary training. No differences were obtained between candidates given this instruction and a control group using two criteria: (1) flight failure elimination; and (2) the number of board meetings for flight difficulties.

In summary, fairly high correlations have been found between work samples on trainers and flight grades in pilot training. However, reported correlations are substantially lower with the pass-fail criterion. This latter result may be attributable to the failure to identify attritions due to factors unrelated to flying proficiency (LeMaster and Gray, 1974).[23] There is also some suggestion that experience on trainers does not increase the probability of ultimate success in training.

3.4.2.4 Light Plane - Both the Navy and Air Force have established Flight Indoctrination Programs (FIP) consisting of instruction in light planes. As shown in Figure 3.4-12, FIP performance measures have proved valuable in predicting several criteria of success in pilot training.

With a Navy sample, Berkshire and Ambler (1963) assessed the validity of FIP instructor ratings and flight grades using a variety of criteria. Instructor ratings had correlations of .23 with academic (preflight) grades, .49 with primary flight grade, .37 with final overall grade, .36 with the pass-fail criterion, .28 with the flight failure elimination criterion, .14 with the ground failure elimination criterion, and .30 with the voluntary withdrawal elimination criterion. FIP flight grades yielded comparable values (see Figure 3.4-12). Similarly, in a comparison of FIP and non-FIP students, FIP students had superior grades throughout flight training and had attrition rates which were approximately 1/2 that of non-FIP students (Ambler and Waters, 1967).[24]

Air Force FIP results are equally impressive. The attrition rate in undergraduate pilot training within the Air Force is approximately 27.3%, with 13.5% of these occurring in the T-41 (light plane) phase. Among FIP students, the overall attrition rate is approximately 20%, with 4 to 6% in the T-41 phase. In contrast, non-FIP students have an overall attrition rate of approximately 34% and a T-41 rate of 18% (Heard, 1970).[25]

In three studies, Flyer and Bigbee (1954, 1955a, 1955b) found substantial correlations between light plane grades and pass-fail type criteria in primary and basic training. For example, Flyer and Bigbee (1955a) found correlations ranging from .29 to .48 with the pass-fail criterion (see Figure 3.4-12). All values were significant at the .05 level of confidence or better. In a second study, correlations were .41 with the pass-fail criterion and .54 with the flight failure

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[23]Long and Varney (1975) related job sample performance to pass-fail and flight grade criteria using multivariate techniques. This study is discussed in Section 3.4.3.

[24]For additional Navy studies, see Ambler (1964) and Ambler and Berkshire (1960).

[25]There is some suggestion that differences in T-41 performance have implications for success in later stages of training. Goebel, et al, (1971) studied the ralationship between T-41 flight grades and T-37 flight grades. Correlations ranged from -.10 to .52. Five of twelve correlations were significant at the .05 level of confidence or better.

elimination criterion in basic training. Both of these values were significant at the .01 level of confidence.

Using several pass-fail criteria and three stages of training (preflight, primary, and basic training), Mullins and Cox (1960) reported comparable results. In four of seven comparisons, eliminations were greater among non-FIP than FIP students (see Figure 3.4-12). Similar findings were reported in a second study (Cox and Mullins, 1959).[26]

In conclusion, measures of performance on light planes have demonstrated validity for the prediction of several criteria of success in pilot training.

3.4.2.5 Sensory-Motor - During World War II, sensory-motor tests made significant contributions to the prediction of success in pilot training. However, due to technical problems, their popularity declined shortly thereafter. Recently, there has been renewed interest in this important domain. Data for this domain are summarized in Figure 3.4-13.

The relevance of sensory-motor tests to piloting proficiency is clearly illustrated by a factor analytic study of flight maneuvers. Fleischman and Ornstein (1960) factor analyzed 24 contact flying maneuver scores in the T-6 aircraft. Six factors were identified: (1) Control Precision (highly controlled muscular movements); (2) Spatial Orientation (judgment of position in three-dimensional space); (3) Multilimb Coordination (coordinated use of arms and legs); (4) Response Orientation (ability to make rapid decisions under changing stimulus conditions); (5) Rate Control (ability to make responses in anticipation of velocity and rate changes); and (6) Kinesthetic Discrimination (involved in maneuvers emphasizing stalls and slow movements of the aircraft). The first five factors were also found in a factor analytic study of 23 tests which included 16 apparatus tests developed during World War II (Fleischman and Hempel, 1956). All of these had factor loadings on the apparatus tests.[27]

As noted earlier, sensory-motor tests were used during World War II for pilot selection. The Army Air Force's Qualifying Examination contained circuits, hidden figures, line length, point distance, and judgment subtests. With an unselected sample of candidates for pilot training during World War II, these tests showed correlations ranging from .16 to .32 with the pass-fail criterion (DuBois, 1947; Flanagan, 1948). Tests producing the highest correlations were Judgment (r = .32) and Hidden Figures (r = .31).

The Aircrew Classification Battery (ACB) also contained a large number of sensory-motor tests. These included tests for rotary pursuit, rudder control, finger dexterity, discrimination reaction time, two-hand coordination, and complex coordination. With an unselected sample of candidates for pilot training during World War II, correlations with the pass-fail criterion ranged from .18 to .42 (DuBois, 1947; Flanagan, 1948). Tests producing the highest correlations were Complex Coordination (r = .42), Discrimination Reaction Time (r = .41), Rudder Control (r = .36), and Two-Hand Coordination (r = .35).

Highly similar findings are reported in subsequent studies employing these sensory-motor tests. Leiman and Friedman (1952) (using the pass-fail criterion in advanced training), and Zaccaria and Cox (1952) (using the pass-fail criterion in primary training) also found highest correlations with the Rudder Control, Complex Coordination, and Two-Hand Coordination tests. This finding is also reported in studies using the flight failure

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[26]For additional Air Force studies, see Boyle and Hagin (1953); and Sutter, Townsend, and Ornstein (1954).

[27]Roff (1953) factor analyzed a large number of psychomotor tests and identified the following six factors: (1) Integrated Coordination, (2) Visuo-Motor Discrimination, (3) Anticipatory Balancing Reaction, (4) Eccentric Pursuit, (5) Visuo-Motor Discrimination: Errors, and (6) Pursuit Learning. These factors also show some similarity to those found by Fleischman and Ornstein (1960).

BALE AND AMBLER (1971) [r, N = 602]	SPATIAL APPERCEPTION TEST	.05 NS																	
CREAGER (1957) [r, N = 2010]	RUDDER CONTROL					.58													
	FINGER DEXTERITY					.11													
	SAM COMPLEX COORDINATION					.35													
	SAM TWO-HAND COORDINATION					.32													
	SAM DISCRIMINATION REACTION TIME					.21													
	SAM ROTARY PURSUIT WITH DIVIDED ATTENTION					.22													
DUBOIS (1947) FLANAGAN (1948) [r, N = 1137]	AIRCREW CLASSIFICATION BATTERY:																		
	SPATIAL ORIENTATION I	.34																	
	SPATIAL ORIENTATION II	.38																	
	ROTARY PURSUIT	.31																	
	TWO-HAND COORDINATION	.35																	
	COMPLEX COORDINATION	.42																	
	RUDDER CONTROL	.36																	
	DISCRIMINATION REACTION TIME	.41																	
	FINGER DEXTERITY	.18																	
	ARMY AIR FORCE QUALIFYING EXAM:																		
	CIRCUITS	.25																	
	HIDDEN FIGURES	.31																	
	LINE LENGTH	.16																	
	POINT DISTANCE	.19																	
	JUDGMENT	.32																	
FLEISCHMAN (1953) [r, N = 285] [r, N = 613-620]	SIX TARGET RUDDER CONTROL					.33													
	DYNAMIC BALANCE					.11/.12													
FLEISCHMAN (1954) [r, N = 936-1022]	DIRECTION CONTROL	.33**				.34**													
	COMPENSATORY BALANCE:																		
	ERRORS	-.21				-.23													
	NUMBER CORRECT	.27				.30													
	SMOOTHNESS	.00				.01													
FLEISCHMAN, AMBLER, PETERSON, AND LANE (1966) [r, N = 575-643]	SPATIAL APPERCEPTION TEST	.07 NS				.10*									.02 NS				
GREENE (1947) [r, N = 88]	INDIRECT VISION TEST																		
	TWO-HAND COORDINATION TEST																		
LANE (1947) [r, N = 37]	MASHBURN SERIAL REACTION TEST																		
	TWO-HAND COORDINATION TEST																		
	JUDGMENT REACTION TEST																		
LEIMAN AND FRIEDMAN (1952) [r, N = 894]	RUDDER CONTROL	.18																	
	FINGER DEXTERITY	.06																	
	COMPLEX COORDINATION	.19																	
	DISCRIMINATION REACTION TIME	.16																	
	SAM ROTARY PURSUIT WITH DIVIDED ATTENTION	.15																	
	TWO-HAND COORDINATION	.19																	
MCGREVY AND VALENTINE (1974) [R, N = 121]	TWO-HAND COORDINATION	.18 NS				.20 NS													
	COMPLEX COORDINATION	.44*				.32 NS													
[R, N = 92]	COMPLEX COORDINATION	.43 NS/ .60*				.41/.50 NS												.43 NS/ .55*	
PAYNE, ROHLES, AND COBB (1952) [r, N = 510-685]	SAM PLANE CONTROL					.27**/.29**													
	SANTA ANA FINGER DEXTERITY					.05 NS/.11**													
	SAM ROTARY PURSUIT WITH DIVIDED ATTENTION					.26**/.37**													
	SAM DISCRIMINATION REACTION TIME					-.24**/ -.26**													
	SAM TWO-HAND COORDINATION					.34**/ .41**													
	SAM COMPLEX COORDINATION					.32**/ .45**													
	SAM RUDDER CONTROL					.42**/ .49**													
	SAM DIRECTION CONTROL					.28**/ .31**													
	SAM COMPENSATORY BALANCE					.24**/ .37**													
	SAM PURSUIT CONFUSION					.26**/ .35**													
	COMPLEX TIMING REACTION WITH MEMORY FOR PROCEDURES					.27**													
VALENTINE (1961) [r, N = 151-172]	AIR FORCE OFFICER QUALIFYING TEST	.02				-.02													
	SPATIAL ORIENTATION I	.08				-.02													
ZACCARIA AND COX (1952) [r, N = 547-1016]	SAM ROTARY PURSUIT WITH DIVIDED ATTENTION	.16/.26																	
	RUDDER CONTROL	.25/.36																	
	FINGER DEXTERITY	.06/.11																	
	SAM COMPLEX COORDINATION	.31/.36																	
	SAM TWO-HAND COORDINATION																		
	SAM DISCRIMINATION REACTION TIME	.21/.27																	

CRITERION																															
TENSION ELIMINATION	TENSION AND AIRSICKNESS ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL - FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP STUDENT-INSTRUCTOR	CRITERION GROUP AVIATION OFFICER CANDIDATE - COLLEGE STUDENT	CRITERION GROUP AVIATION OFFICER CANDIDATE - DROP ON REQUEST	CRITERION GROUP ADJUSTED-MALADJUSTED	CRITERION GROUP AIRCRAFT/PILOT ASSIGNMENT	EXPERIENCE OF MOTION SICKNESS/ AIRSICKNESS	EXPERIENCE OF VERTIGO	GRADES-ACADEMIC	GRADES-FLIGHT	GRADES-MILITARY	GRADES-OVERALL	MILITARY/LEADERSHIP RANK	MOTIVATIONAL MEASURES	STAGE OF ATTRITION	TIME TO SOLO OR COMPLETE TRAINING	TRAINING PHASE
																						FLIGHT BASIC THROUGH ADVANCED
		.02 NS																				FLIGHT PRIMARY
			.43 NS/ .55*											-.09 NS/.26* -.13 NS/ .30** -.38/.25 -.29/.28 -.24/.29							FLIGHT TRAINING FLIGHT ADVANCED TRAINING FLIGHT
													.03	.02								PRIMARY BASIC PRIMARY

G MEASURES OF SENSORY-MOTOR SKILLS TO CRITERIA OF SUCCESS IN TRAINING

elimination criterion (Creager, 1957; Payne, Rohles, and Cobb, 1952) (see Figure 3.4-13).[28]

Several studies stress the importance of spatial factors for aircrew selection (Ambler and Smith, 1974; Anderson, Fruchter, Manuel, and Worchel, 1954; Roff, 1951; Taylor and Parker, 1959). The ACB contained Spatial Orientation I and Spatial Orientation II tests. With an unselected sample of candidates for pilot training during World War II, both tests proved to be valuable. Correlations with the pass-fail criterion were .34 (Spatial Orientation I) and .38 (Spatial Orientation II) (DuBois, 1947; Flanagan, 1948). However, with other spatial tests, such as the Spatial Orientation I test of the Air Force Officer Qualifying Test (Valentine, 1961) and the Spatial Apperception Test (Bale and Ambler, 1971; Fleischman, et al, 1966), relationships with several criteria of success in training are poor (see Figure 3.4-13).

Overall, these sensory-motor tests which were popular during World War II and for a short time afterward were found to be valid for the prediction of success in pilot training and, in fact, they were more valid than paper-and-pencil tests in use at that time. The reason for their discontinuation is explained by McGrevy and Valentine (1974):

> "Use of psychomotor assessments in the Air Force pilot selection program were discontinued in the early 1950s because of the expense and difficulty of maintaining and calibrating the required equipment under decentralized testing conditions." (p. 5)

Fortunately, technological advancements have stimulated renewed interest in sensory-motor tests as selection devices. Under Air Force sponsorship, Passey and McLaurin (1966), after an extensive review of the perceptual-psychomotor literature, produced an extensive list of "critical behavior functions" for aircrew performance. These functions included factors such as motor skill acquisition rate, perceptual speed, kinesthetic discrimination, performance consistency, and psychomotor ability.

In 1970, the Air Force established a research facility at Lackland Air Force Base for the development of psychomotor selection devices. The first tests developed were modeled after two psychomotor tests which were part of the ACB and showed good validity in World War II. These are Complex Coordination and Two-Hand Coordination (McGrevy and Valentine, 1974; Sanders, Valentine, and McGrevy, 1971). Scores on these tests were validated against several pass-fail type criteria using multiple regression (McGrevy and Valentine, 1974). Scores for two-hand coordination had multiple correlations of .18 with the pass-fail criterion and .20 with the flight failure elimination criterion. Neither of these values reached significance. Scores for complex coordination had multiple correlations ranging from .43 to .60 with the pass-fail criterion (3 of 6 values were statistically significant), .32 to .50 with the flight failure elimination criterion (of 6 values, 0 were statistically significant), and .43 to .55 with the voluntary withdrawal elimination criterion (2 of 5 values were statistically significant). Although many of these correlations failed to be statistically significant, those for complex coordination are relatively large considering the problem of a highly restricted range.[29]

In summary, sensory-motor tests were found to be valid for the prediction of success in pilot training during World War II. These tests appear to merit the renewed attention they are presently being given.

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[28] Other psychomotor tests assessed are the Six Target Rudder Control and Dynamic Balance Tests (Fleischman, 1953), and the Direction Control and Compensatory Balance Tests (Fleischman, 1954). Scores for the Direction Control Test were significantly related to the pass-fail criterion and the flight failure elimination criterion in primary training (see Figure 3.4-13).

[29] Samples were Air Force officer trainees who graduated from the School of Military Science-Officer and entered undergraduate pilot training.

3.4.2.6 Situational Tests - These tests use situations modeled after those expected to occur on the job. This type of testing not only permits measurement for possession of the requisite skills but also for factors such as motivation to perform and directionality of effort, i.e., whether or not energy is channeled into goal-oriented behavior (Fiske, 1954; Weislogel, 1954). In common with the job sample approach, this type of testing also allows for the complex interaction of abilities (Fiske, 1954).

Unfortunately, only one study was found which addressed the validity of this approach. Weislogel (1954) reviewed two studies conducted by the American Institutes for Research. Both of these studies focused upon leadership tests. In the first study, a Leadership Reaction Test was given to 516 soldiers enrolled in a Leadership Course at two Army posts. This was a field test staged in maneuver territory. Scores consisted of observer ratings of behavior (classified as effective or ineffective). The correlation between these scores and leadership ratings (a composite of peer and faculty ratings) was .46. In the second study, 343 Air Force Officer Candidates were given the Conference Table Test which consisted of 16 conference-type leadership situations. Scores were observer ratings of behavior as effective or ineffective. These scores had correlations of .21 with leadership ratings by flightmates, .24 with leadership ratings by tactical officers, and .25 with final military class grade.

Although data are scarce, it appears that this approach may merit further development. For example, Berkun, Bialek, Kern, and Yagi (1962) found this type of approach valuable for inducing psychological stress as indicated by behavioral and physiological measures. Among the situations producing the strongest stress reactions were a simulated aircraft emergency and a simulated disruption of a military exercise by misdirected artillery shells. Although no validity data were provided, these data suggest that this may be a sensitive tool for measuring differences in reaction to stress in candidates for pilot training.

3.4.3 Multiple Prediction - Studies reviewed in this section are concerned with the prediction of success in pilot training from more than one variable. Typically, predictors are chosen from several domains.

In some cases, fairly strong relationships have been found, with several studies reporting multiple correlation values in excess of .50 (see Figure 3.4-14). For example, Levine and Tupes (1952), using a combination of aptitude, biographical, and motivational variables, found correlations of .61 with the motivational elimination criterion, .62 with the flight failure elimination criterion, and .51 with the administrative elimination criterion in training.

Of special interest are studies which have addressed the question of whether or not addition of a new variable significantly increases the multiple correlation found with selection tests currently in use. From this type of analysis, one can determine whether a variable is accounting for presently unexplained variance in the criterion measure.

Selection tests currently used by the Navy include the Aviation Qualifying Test (AQT), Mechanical Comprehension Test (MCT), Spatial Apperception Test (SAT) and the Biographical Inventory (BI). Multiple correlations obtained with these measures have been significantly augmented by the addition of several biographical variables. Wherry and Hutchins (1965) computed multiple correlations obtained with several selection variables (age, education, AQT, SAT, MCT, BI, and preflight variables) using the pass-fail, voluntary withdrawal elimination, and flight failure elimination criteria. These correlations were computed with both officer and nonofficer samples. In four of six cases, significant increases in multiple correlation values were found when procurement source was included as a predictor. Similarly, Bale and

N = SAMPLE SIZE
NS = $p > .05$
* = $p \leq .05$
** = $p \leq .01$

REFERENCE AND STATISTIC	PREDICTOR	CRITERION: PASS-FAIL ATTRITE	ADMINISTRATIVE ELIMINATION	AIRSICKNESS ELIMINATION	FEAR OF FLYING ELIMINATION	FLIGHT FAILURE ELIMINATION	GROUND FAILURE ELIMINATION	MEDICAL ELIMINATION	MOTIVATIONAL ELIMINATION	NOT AERONAUTICALLY ADAPTED ELIMINATION	NOT PHYSICALLY ADAPTED ELIMINATION	PURIFIED PASS-FAIL	TENSION ELIMINATION	TENSION AND AIRSICKNESS ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL - FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP STUDENT-INSTRUCTOR	CRITERION GROUP AVIATION OFFICER CANDIDATE - COLLEGE STUDENT	CRITERION GROUP AVIATION OFFICER CANDIDATE - DROP ON REQUEST	CRITERION GROUP ADJUSTED-MALADJUSTED
BALE AND AMBLER (1971) [CUMULATIVE R, N = 602]	MECHANICAL COMPREHENSION	.17																				
	BIOGRAPHICAL INVENTORY	.22																				
	GRADE POINT AVERAGE 2.0-2.49	.24																				
	PRIVATE PILOT LICENSE	.25																				
	MOTIVATION TO FLY SINCE AGE 22	.26																				
	ATTENDED 3 COLLEGES OR MORE	.27																				
	COLLEGE IN PACIFIC COAST	.28																				
	COMMERCIAL PILOT'S LICENSE	.28																				
	FLOWN LESS THAN TWICE COMMERCIALLY	.29																				
	MEMBER COLLEGE FLYING CLUB	.30																				
	MOTIVATION TO FLY SINCE AGE 15-17	.30																				
	ATTENDED COLLEGE GREATER THAN 16,000	.30																				
	MOTIVATION FLY BEFORE AGE 12	.30																				
BERKSHIRE AND AMBLER (1963)** [R, N = 196]	AVIATION QUALIFYING TEST AND FLIGHT APTITUDE RATING	.24				.22	.27								.42							
	ABOVE VARIABLES PLUS TWO MEASURES OF IN-DOCTRINATION PERFORMANCE (INSTRUCTOR'S PREDICTION FORM AND INSTRUCTOR'S FLIGHT GRADE)	.39				.38	.29								.48							
FLEISCHMAN, AMBLER, PETERSON, AND LANE (1966) [R, N = 575-643]	BIOGRAPHICAL INVENTORY, AVIATION QUALIFYING TEST, MECHANICAL COMPREHENSION TEST, SPATIAL APPERCEPTION TEST, ACADEMIC GRADES AND PEER RATING	.29				.36									.15							
	ABOVE VARIABLES PLUS FIVE PERSONALITY TEST MEASURES (TAYLOR MANIFEST ANXIETY, ALTERNATE MANIFEST ANXIETY, PENSACOLA Z, ADJECTIVE CHECK LIST, AND CATTELL'S 16 PERSONALITY FACTOR QUESTIONNAIRE)	.38				.43									.27							
GREENE (1947) [R, N = 88]	INDIRECT VISION TEST, MENTAL ABILITY TEST, MECHANICAL COMPREHENSION, DESIRE TO FLY INVENTORY, AVIATION INFORMATION TEST, AND TWO-HAND COORDINATION TEST																					
HOLLANDER (1952) [R, N = 299]	PREFLIGHT ACADEMIC GRADES:																					
	FINAL AEROLOGY																					
	FINAL CODE																					
	FINAL ENGINES																					
	FINAL ESSENTIALS OF NAVAL SERVICE																					
	FINAL NAVIGATION																					
	FINAL PRINCIPLES OF FLIGHT																					
	NAVY GRADE	.60																				
HUTCHINS (1964) [CUMULATIVE R, N = 1636]	BIOGRAPHICAL INVENTORY														.09							
	RANK														.11							
	MECHANICAL COMPREHENSION														.13							
	AVIATION QUALIFYING TEST														.15							
[R]	ABOVE VARIABLES MINUS RANK														.13							
[CUMULATIVE R]	MECHANICAL COMPREHENSION	.21																				
	BIOGRAPHICAL INVENTORY	.26																				
	RANK	.26																				
	SPATIAL APPERCEPTION	.27																				
[R]	ABOVE VARIABLES MINUS RANK	.26																				
[CUMULATIVE R]	BIOGRAPHICAL INVENTORY														.07							
	RANK														.09							
	AVIATION QUALIFYING TEST														.11							
	AERODYNAMICS GRADE														.12							
	MECHANICAL COMPREHENSION														.12							
	PHYSIOLOGY GRADE														.13							
	PHYSICAL TRAINING GRADE														.13							
	SPATIAL APPERCEPTION														.14							
[R]	ABOVE VARIABLES MINUS RANK														.13							
[CUMULATIVE R]	AERODYNAMICS GRADE	.21																				
	BIOGRAPHICAL INVENTORY	.26																				
	NAVIGATION GRADE	.28																				
	MECHANICAL COMPREHENSION	.28																				
	AVIATION QUALIFYING TEST	.29																				
	RANK	.29																				
	PHYSIOLOGY GRADE	.30																				
	SPATIAL APPERCEPTION	.30																				
[R]	ABOVE VARIABLES MINUS RANK	.29																				
LANE (1947) [R, N = 37]	JUDGEMENT REACTION TEST, OHIO STATE PSYCHOLOGICAL EXAM, BIOGRAPHICAL INVENTORY, MECHANICAL COMPREHENSION, DESIRE TO FLY INVENTORY, MASHBURN SERIAL REACTION TEST, TWO HAND COORDINATION TEST, AVIATION INFORMATION, AND SELF ADMINISTERING TEST OF MENTAL ABILITY																					

FIGURE 3.4–14 STATISTICAL RESULTS OF FIXED WING PILOT SELECTION STUDIES USING MULTIPLE CORRELATION FOR THE PRE

MCDONNELL DOUGLAS CORPORATION

CRITERION																								
TENSION ELIMINATION	TENSION AND AIRSICKNESS ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL - FLIGHT FAILURE ELIMINATION	BOARD APPEARANCES	CRITERION GROUP STUDENT-INSTRUCTOR	CRITERION GROUP AVIATION OFFICER CANDIDATE - COLLEGE STUDENT	CRITERION GROUP AVIATION OFFICER CANDIDATE - DROP ON REQUEST	CRITERION GROUP ADJUSTED- MALADJUSTED	CRITERION GROUP AIRCRAFT-PILOT ASSIGNMENT	EXPERIENCE OR MOTION SICKNESS/ AIRSICKNESS	EXPERIENCE OR VERTIGO	GRADES-ACADEMIC	GRADES-FLIGHT	GRADES-MILITARY	GRADES-OVERALL	MILITARY-LEADERSHIP RANK	MOTIVATIONAL MEASURES	STAGE OF ATTRITION	TIME TO SOLO OR COMPLETE TRAINING	TRAINING PHASE
																							TRAINING
		42											51	40		42							TRAINING
		48											55	51		60							FLIGHT
		15																					
		27																					TRAINING
														23 NS/ 49**									BASIC
		09 11 13 15																					TRAINING
		13																					
		07 09 11 12 13 13 13 14																					
		13																					
														51 NS/ 71**									FLIGHT

TUDIES USING MULTIPLE CORRELATION FOR THE PREDICTION OF CRITERIA OF SUCCESS IN TRAINING

n = SAMPLE SIZE
NS = $p > .05$
* = $p \leq .05$
** = $p \leq .01$

REFERENCE AND STATISTIC	PREDICTOR	CRITERION: PASS-FAIL ATTRITE	ADMINISTRATIVE ELIMINATION	AIRSICKNESS ELIMINATION	FEAR OF FLYING ELIMINATION	FLIGHT FAILURE ELIMINATION	GROUND FAILURE ELIMINATION	MEDICAL ELIMINATION	MOTIVATIONAL ELIMINATION	NOT AEROMEDICALLY ADAPTED ELIMINATION	NOT PHYSICALLY ADAPTED ELIMINATION	PURIFIED PASS-FAIL	TENSION ELIMINATION	TENSION AND AIRSICKNESS ELIMINATION	VOLUNTARY WITHDRAWAL ELIMINATION	VOLUNTARY WITHDRAWAL AND FLIGHT FAILURE ELIMINATION	VOLUNTARY WITHDRAWAL FLIGHT FAILURE ELIMINATION	BOARD APPRAISANCES	CRITERION GROUP STUDENT - NEITHERTON	CRITERION GROUP AVIATION OFFICER CANDIDATE - COLLEGE STUDENT	CRITERION GROUP AVIATION OFFICER CANDIDATE - DROP ON REQUEST	CRITERION GROUP ADJUSTED MALADJUSTED	CRITERION GROUP AIRCRAFT PILOT ASSIGNMENT	EXPERIENCE (D MOTION SICKNESS) AIRSICKNESS	EXPERIENCE (D VERTIGO	GRADES - ACADEMIC
LEMASTER AND GRAY (1974) [R, N = 71-128]	JOB SAMPLE MEASURES: MANEUVERS, SYSTEMS MANAGEMENT, *FLYING PROCEDURES*, AND AIR FORCE OFFICER QUALIFYING TEST: PILOT PERCENTILE, NAVIGATOR PERCENTILE, QUANTITATIVE PERCENTILE, QUALITATIVE PERCENTILE, OFFICER QUALITY PERCENTILE	45**																							
	AIR FORCE OFFICER QUALIFYING TEST PERCENTILES MINUS JOB SAMPLE MEASURES	30																							
LEVINE AND TUPES (1962) [R, N = 430-583]	AIRCREW CLASSIFICATION BATTERY, GENERAL INFORMATION BIOGRAPHICAL DATA BLANK, PRACTICAL JUDGMENT ATTITUDE SURVEY, AND BIOGRAPHICAL INVENTORY		51						61							62										
LONG AND VARNEY (1975) [R, N = 105]	SIX FACTOR SCORES DERIVED FROM AIR FORCE OFFICER QUALIFYING TEST, REFERENCE BATTERY, PSYCHOMOTOR BATTERY, AND TWENTY FACTOR SCORES DERIVED FROM PERFORMANCE ON GENERAL AVIATION TRAINER-1																								
[R, N = 114-145]	TWENTY FACTOR SCORES FROM PERFORMANCE ON GENERAL AVIATION TRAINER-1 ONLY	34/ 37 44				26																			
MCGREVY AND *VALENTINE (1974)* [R, N = 121]	AIR FORCE OFFICER *QUALIFYING TEST* (13 SUBTESTS)	37 NS				32 NS																			
	ABOVE VARIABLES PLUS TWO-HAND COORDINATION AND COMPLEX COORDINATION	56 NS				47 NS																			
[R, N = 96]	AIR FORCE OFFICER QUALIFYING TEST (5 COMPOSITES)	31 NS				31 NS										31 NS									
	ABOVE VARIABLES PLUS COMPLEX COORDINATION	50 NS/ 62*				47 NS/ 56 NS										51 NS/ 61*									
MICHAEL (1949) [R, N = 356-815]	AIRCREW CLASSIFICATION BATTERY TESTS	42/ 60																							
NEUMAN (1968) [R, N = 87-116]	PRIMARY SELECTION TESTS, PSYCHOMOTOR ABILITY, AND DEFENSE MECHANISM TEST	41/ 43																							
SHANNON AND WAAG (1973) [CUMULATIVE *R, N = 171*]	EXPERIENCE LEVEL, FORMATION STAGE GRADE, TRANSITION STAGE GRADE, *FLIGHT APTITUDE RATING*, BASIC INSTRUMENTS STAGE GRADE, AVIATION QUALIFYING TEST, INSTRUMENT NAVIGATION STAGE GRADE, CARRIER QUALIFICATION STAGE GRADE																								
TUPES (1955) [R, N = 474-527]	ROTC PHYSICAL PROFICIENCY TESTS: DIPS, BASKETBALL THROW, SHUTTLE RUN, SENIOR ROTC PERSONNEL INVENTORY, ROTC ATTITUDE SURVEY, AND AVIATION CADET-OFFICER CANDIDATE QUALIFICATION TEST: CURRENT AFFAIRS, ENGLISH USAGE, JUDGMENT, AERIAL ORIENTATION, ARITHMETIC REASONING																								
WHERRY AND HUTCHINS (1965) [R, N = 726-1346]	AGE, EDUCATION, AVIATION QUALIFYING TEST, MECHANICAL COMPREHENSION, SPATIAL APPERCEPTION, BIOGRAPHICAL INVENTORY, LEADERSHIP, OFFICER-LIKE QUALITIES, PEER RATING, PHYSIOLOGY GRADE, MATHEMATICS GRADE, PHYSICS GRADE, AVIATION SCIENCE GRADE, ENGINES GRADE, NAVAL ORIENTATION GRADE, NAVIGATION GRADE, AERODYNAMICS GRADE, STUDY SKILLS GRADE, AND PHYSICAL TRAINING GRADE	23/ 34				23/26										15/ 19									
	ABOVE VARIABLES PLUS PROCUREMENT	27/ 34				24/ 28										21/ 25									
WRIGLEY (1952) [R, N = 374]	INTELLIGENCE TEST, AMOUNT OF SCHOOLING, *GROUND EXAMINATIONS*, SPATIAL RELATIONS (4 TESTS), MUSCULAR COORDINATION (3 MEASURES), COMPLEX REACTION TIME, AND AGE																								

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FIGURE 3.4–14 STATISTICAL RESULTS OF FIXED WING PILOT SELECTION STUDIES USING MULTIPLE CORRELATION FOR THE PRED

BOARD APPEARANCES	CRITERION GROUP STUDENT INSTRUCTION	CRITERION GROUP AVIATION OFFICER CANDIDATE - COLLEGE STUDENT	CRITERION GROUP AVIATION OFFICER CANDIDATE - GROUP ON REQUEST	CRITERION GROUP ADJUSTED MALADJUSTED	CRITERION GROUP AIRCRAFT PILOT ASSIGNMENT	EXPERIENCE OF MOTION SICKNESS/ MALADIES	EXPERIENCE OF VERTIGO	GRADES - ACADEMIC	GRADES - FLIGHT	GRADES - MILITARY	GRADES - OVERALL	MILITARY LEADERSHIP RANK	MOTIVATIONAL MEASURES	STAGE OF ATTRITION	TIME TO SOLO OR COMPLETE TRAINING	TRAINING PHASE
									64** 76**							T-37 TRAINING
									NS/24 NS							T-37 TRAINING TRAINING
									46/ 52							T-41
									28/ 41							T-41 T-41 AND T-37 TRAINING
																TRAINING FLIGHT
									31 43 46 48 49 50 50 51							REPLACEMENT AIR GROUP TRAINING
									33**/ 42**			29**/ 34**				PREFLIGHT THROUGH FLIGHT
									15 NS/ 64*							TRAINING

COPY

ULTIPLE CORRELATION FOR THE PREDICTION OF CRITERIA OF SUCCESS IN TRAINING (Continued)

Ambler (1971) found that biographical inventory scores (Flight Background Inventory and College Background Inventory) significantly augmented present selection variables in predicting the pass-fail and voluntary withdrawal elimination criteria (see Figure 3.4-14).

Three other variables reportedly augment present Navy selection variables. Fleischman, et al, (1966) assessed whether personality inventory scores (Taylor Manifest Anxiety Scale, Alternate Manifest Anxiety Scale, Pensacola Z Scale, Adjective Check List, and Catell's 16 Personality Factor Questionnaire) augmented prediction from selection variables (AQT, MCT, SAT, BI, preflight grades, and peer ratings). Multiple correlations with three criteria (pass-fail, flight failure elimination, and voluntary withdrawal elimination) were significantly increased by the addition of these personality variables (see Figure 3.4-14).

Waag, Shannon, and Ambler (1973) found that instructor ratings (ratings on Probability of Getting Wings, Motivation, Headwork, and Reaction to Stress) increased the validity derived from selection variables (AQT, MCT, SAT, BI, and grades available before primary training). With a sample of Aviation Officer Candidates, the multiple correlation with the pass-fail criterion was .24 excluding instructor ratings and .32 with the inclusion of these ratings. These correlations were .25 and .30, respectively, with a sample of Officers under Instruction. Both correlations were significantly increased by the addition of instructor ratings.

Finally, Berkshire, et al, (1963) found that Flight Indoctrination Program (FIP) grades (instructor ratings and flight grades) increased the prediction of several criteria derived from the AQT and Flight Aptitude Rating. Criteria were preflight grade, primary flight grade, final overall grade, flight failure elimination, ground failure elimination, voluntary withdrawal elimination, and pass-fail. With the exception of the ground failure elimination criterion, all multiple correlations were significantly increased with the addition of FIP grades. For example, the multiple correlation with the pass-fail criterion was .24 excluding FIP grades and .39 with the inclusion of these grades.

Both sensory-motor and job sample measures have been found to enhance prediction from the Air Force Officer Qualifying Test (AFOQT), a selection test currently used by the Air Force. McGrevy and Valentine (1974) reported significant increases in multiple correlations with the pass-fail criterion when sensory-motor test scores (Two-Hand Coordination and Complex Coordination) were added to the predictors. In one study, the multiple correlation was .37 excluding these sensory-motor scores and .56 with their inclusion. Similarly, in a second study, addition of scores on Complex Coordination significantly augmented prediction of the pass-fail criterion.

Long and Varney (1975) contrasted the validity of job sample measures and Air Force Reference measures as predictors of grades in the T-41 phase of training. Air Force Reference measures were six factor scores derived from a Reference Battery, Psychomotor Battery, and the AFOQT. Job sample measures were 20 factor scores derived from a large number of maneuver scores on a modified GAT-1 trainer. Multiple correlations with grades (fair or deficient versus excellent or waivered) were .52 when Reference measures were included and .28 and .41 (with different sample sizes) without these Reference measures. Therefore, job sample measures alone yielded fairly high correlations with T-41 grades. In addition, relatively high correlations were reported between job sample measures and the pass-fail and flight failure elimination criteria in T-41 and T-37 phases. Similarly, LeMaster and Gray, (1974) found that job sample measures enhanced prediction from the AFOQT with two criteria (see Figure 3.4-14).

In summary, these studies suggest that the prediction of success in training within the Navy and Air Force can be markedly improved with the addition of factors to present selection methods.

These factors include instructor ratings, FIP grades, sensory-motor and job sample measures, and biographical and personality variables.

3.4.4 Statistical and Methodological Issues - In the introduction to Section 3.4, the reader was urged to exercise caution in interpreting this literature, especially in cases where repeated statistical tests were used (e.g., more than one correlation or t test is computed on a single set of data). The problem posed is that the probability of obtaining a significant result by chance increases as you increase the number of tests or comparisons (Kirk, 1968). For example, when the comparisons are independent,[30] this probability may be obtained by the formula:

$$1 - (1-\alpha)^C$$

where α = the level of significance

C = the number of comparisons made.

Consequently, when adopting a .05 α level, the effective α level is approximately .0975 when two comparisons are made, .1426 when three comparisons are made, etc. Therefore, as the number of tests increases, the number of spurious differences also increases. This statistical problem was a frequent one among studies reviewed in Sections 3.4.1 and 3.4.2. One solution is to use multivariate techniques, one of which is the multiple correlation employed in studies reviewed in Section 3.4.3.[31]

A second statistical difficulty is posed by the restricted range present in the majority of studies reviewed. Typically, analyses were computed on samples of candidates selected for entrance into pilot training. These are relatively homogeneous populations. The effect of a restricted range is to artifically lower the magnitude of the correlation (McNemar, 1969). Thus, correlations reported are under-estimates of the degree of relationship between variables. Although techniques are available to correct for a restricted range (McNemar, 1969), they have rarely been applied.[32]

As noted in the introduction, most studies have favored a pass-fail type of criterion for success in training. The pass-fail criterion only allows for relatively crude evaluations. No distinction is made between those candidates who have great difficulty succeeding and those who progress through pilot training with little or no difficulty (McGehee, 1951; Rosenberg, 1954). Rosenberg (1954) suggests time to complete training as a more useful criterion in that it would permit this distinction. At a more general level, Dunnette (1963) recommends that we use multiple measures of behavior rather than focusing on a single criterion. This seems to be a reasonable approach to selection when we consider the complexity of the problem. Flying fighter planes is a complex skill, and, as such, it may be more efficient to look at several criteria, each tapping different components of this ability.

Finally, as noted by McGehee (1951), often there is no evaluation of selection methods beyond training. This is evidenced by the paucity of combat research reviewed in Sections 3.2 and 3.3. Presumably, the purpose of selection is to guarantee success on the job, not just success in training. An implicit assumption in the training research is that there is a strong relationship between success in training and success in combat. However, this assumption is not necessarily valid (see Section 3.2.1).

In reviewing these issues, it is not our intent to discredit training research. Indeed, these data are used as one source for hypothesis generation (see Section 4). The purpose of this evaluation is to point out some of the areas which can be markedly improved upon in subsequent selection research. Most important of all is the need for combat-related validation studies.

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[30] Independent comparisons are those which are orthogonal, i.e., information used in the comparisons is nonoverlapping (Kirk, 1968).

[31] Applications of other multivariate techniques may be found in Lockman (1953, 1955) and Thaler (1970).

[32] Exceptions include studies done within the Army Air Force's Psychology Program.

3.4.5 Summary - Since World War II, a large variety of predictors has been studied in relation to criteria of success in pilot training. These predictors fall within 13 distinct content domains. Seven of these domains focus on characteristics (aptitude, biographical, medical, motivational, personality, reaction to stress, and social factors), whereas six domains deal with critical skills for fighter pilots (aviator skills, knowledges, and tasks; information processing rate; job sample measures; light plane measures; sensory-motor skills; and measures in situational tests). Most studies reviewed have employed a pass-fail type of criterion.

Although statistical/methodological problems are present in many of these studies (e.g., the use of repeated statistical tests, failure to correct for a restricted range, and insensitivity of the pass-fail type of criterion), several conclusions may be drawn. With the exception of medical factors (physical fitness test scores) and most paper-and-pencil measures of reaction to stress, these categories of predictors have shown relationships to or have shown potential for the prediction of criteria of success in pilot training.[33]

Multiple prediction studies (i.e., studies concerned with the prediction of success in training from more than one predictor) have been the most revealing. These studies found that the prediction of training success can be significantly augmented by adding several factors to current selection measures. These factors include instructor ratings, Flight Indoctrination Program grades, sensory-motor and job sample measures, and biographical and personality variables. These data are employed in Section 4 to generate a profile of the combat effective fighter pilot.

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[33] More detailed summary statements may be found at the end of Subsections 3.4.1.1 to 3.4.1.7 and 3.4.2.1 to 3.4.2.6, respectively.

3.5 FOREIGN PILOT SELECTION PROGRAMS

Three foreign fighter pilot selection programs will be considered in this section: the current Israeli program, and the German and Japanese programs of World War II.[1] A significant factor to bear in mind as we review these foreign pilot selection programs is that none of them has scientifically correlated selection tests with ultimate fighter pilot combat effectiveness. Nevertheless, we feel that each of these programs is worthy of review. The Israeli program includes some assessment techniques not used in other pilot selection programs, and the review of foreign programs during World War II identify certain pitfalls which might be avoided. The factors tested for in these programs, at least by implication, provide another source of information upon which we can build a comprehensive profile (hypotheses) of the combat effective fighter pilot which we will integrate and show in Section 4 of this document.

Our discussion of the Israeli program is unclassified. It has been pieced together from the open literature and a personal interview with an Israeli selection specialist[2] who had received prior permission to discuss unclassified details of the Israeli fighter pilot selection program with us. The German and Japanese programs of World War II were reported upon by prominent American psychologists shortly after the cessation of hostilities with these countries (Fitts, 1946; Geldard and Harris, 1946).

3.5.1 The Israeli Program - In terms of combat effectiveness, many consider the Israeli Air Force (IAF) to be the finest in the world. If the Israeli air-to-air combat claims are to be believed (60 to 1) then, indeed, they are in a class by themselves (Cook, 1972). Many factors undoubtedly contribute to this combat effectiveness aggregate, including the relatively constant weather and terrain conditions, the Israelis' knowledge of their enemies, the constant state of national military alert, the high state of pilot readiness, (pilots are reported to make 400 to 500 air combat sorties per year) as well as an underlying state of national pride and motivation. One other element that may be contributing to the combat effectiveness of the Israeli air-to-air combat fighter pilot is the IAF pilot selection program.

The Israeli selection specialist we interviewed was quick to point out to us that any appraisal of the Israeli selection and training program should be conducted with an awareness of the Israelis' unique, sociopolitical environment. Within this context, the Israeli pilot is considered the most elite of all of their fighting arms. Additionally, any consideration of the Israeli program must start from an appreciation of the fact that they have universal military service.

Before describing the IAF pilot selection and training program, let's look at a quote drawn from an Air University Study by Cook (1972).

> "What the Israelis have learned is that in an air force, numbers are not important... quality is the deciding factor. Major General Ezer Weizman, former Air Force Chief, wrote prophetically in 1962 that numbers don't count; only effective missions do. If one can match the enemy sortie for sortie, then the outcome will be determined primarily by the competence of the pilots. This philosophy accounts for the concentration of interest on men rather than machines; or, as he put it: '. . .In an age of sophisticated weapons we try to make the man in the cockpit count above everything....'
>
> "It was Weizman who insisted that the French build cannons into the Mirages the Israelis ordered in 1958-1959 even though the supersonic jets had been designed to carry only missiles. He wanted cannons not only because they are simple, reliable and comparatively inexpensive weapons, but also because guns can serve a dual purpose: they are extremely effective in both aerial and ground attack....
>
> "Effective, that is, if the pilots are highly skilled; and it is upon just this premise that Brigadier General Mordecai Hod, current

[1] For reviews of other foreign aircrew selection programs, see Air Ministry (1947), Manning and Yellowlees (1949), Parry (1947), Signori (1949), Tromp (1962), Vernon and Parry (1949), Want (1962), and Wooton (1972).

[2] A professionally trained and experienced experimental psychologist.

IAF commander, has built his combat doctrine. Aerial tactics are planned on the basic assumption that Israeli pilots are far superior to the enemy. In General Hod's opinion, two IAF aircraft--a leader and a wingman to keep him clear-- are sufficient for any aerial battle, no matter how many enemy aircraft are involved. Like Weizman, he feels that '... over-sophistication, computerized answers, systems analysis and cost effectiveness have brought the flying world away from the few sound basic principles of air war....'

"Consequently, the emphasis is upon individual excellence, courage, and a deep sense of personal responsibility; and these are the qualities the IAF seeks to instill in its pilots during their training....

The Israelis have established a pilot training program that is both intensive and costly; it takes about 20 months and approximately $150,000 to train one Israeli fighter pilot. By contrast, our present 48 week UPT program costs $85,970. Applicants are meticulously chosen only from the best of the country's young men. Although college is not required, all must have completed high school and all must be volunteers. Most are about 18 years old and more than half come direct from the kibbutzim....

"The screening process is extremely rigorous; although the Israelis have neither confirmed nor denied it, several observers have reported that only one out of 300 entrants actually becomes an Israeli pilot. Much of the screening is based on intense psychological testing on the ground, personally observed by instructor pilots as well as psychologists. Cadets in groups are assigned physical problems--such as getting everyone across a small stream within a certain time limit---using only the materials at hand. Instructors can thus determine at first hand which ones possess qualities of leadership and innovation. Flexibility and the ability to improvise are more highly prized than simply the capability to follow procedures." (pp. 36-38)

In an overview, Cook (1972) has captured the essence of the IAF pilot selection and training program. More detail is given in Figure 3.5-1 which shows an overview of the Israeli pilot selection and training program from the initial testing through ultimate assignment to operational air-to-air fighter aircraft.

The selection process starts when Israeli boys reach the age of 17 1/2 years. The IAF which has first call on these individuals, uses four initial selection (screening) criteria. They are:

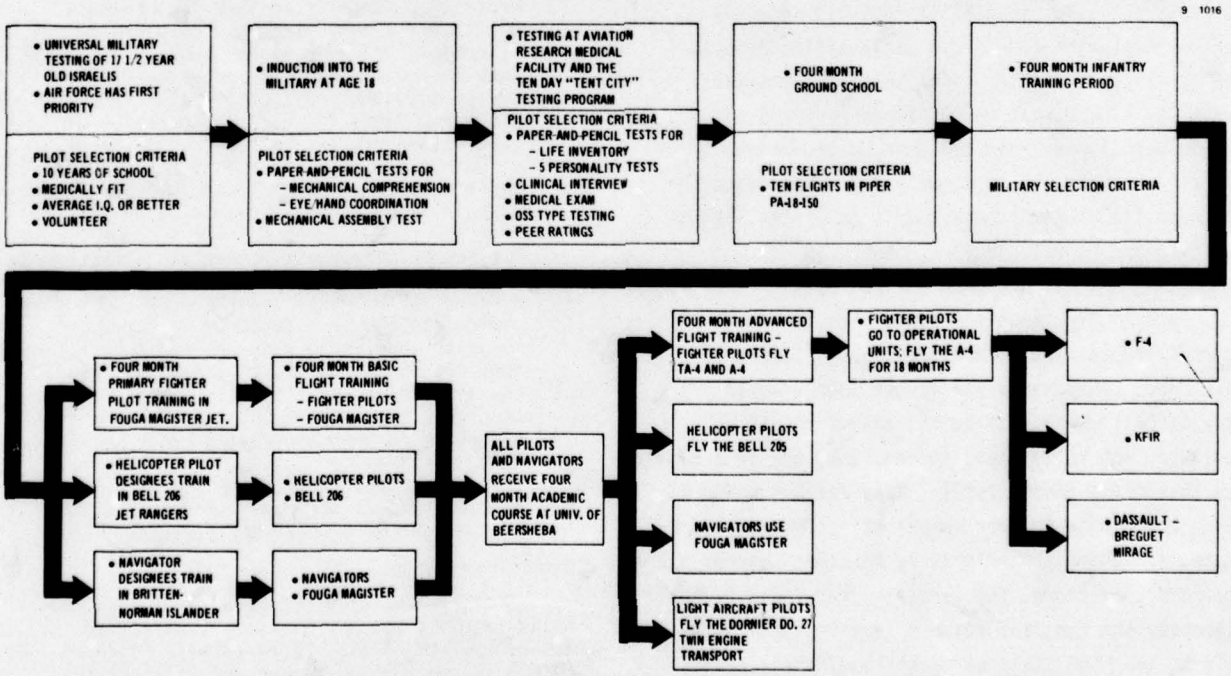


FIGURE 3.5-1 FLOW DIAGRAM OVERVIEW OF THE ISRAELI AIR FORCE PILOT SELECTION AND TRAINING PROGRAM

- o They must be volunteers (Some are selected on the basis of their test scores but may drop themselves from consideration.)

- o They must be medically fit

- o They must "pass" two I.Q. tests (the Raven Matrices, a non-verbal embedded figures test; and the Otis, which gives a verbal I.Q. Measure) (Candidates need only be of average intelligence to go forward.)

- o Candidates must have ten years of formal schooling (This seemingly low requirement was specifically instituted in order that pilot candidates from the various kibbutzim would not be eliminated.)

Candidates who pass this initial screening are tested again immediately following induction at 18 years of age. The following tests are administered at this time:

a. A paper-and-pencil, forced choice, mechanical comprehension test.

b. A mechanical comprehension test involving assembly of a small mechanical apparatus.

c. An eye/hand coordination test. This consists of a pencil through a maze test in which time and accuracy are measured.

Only a small number drop out at this stage, while the remaining go on to the Institute of Aviation Research Medicine facility. Two additional paper-and-pencil psychological tests are administered at this point. The first consists of a detailed background and life inventory test hitting at elements of school, home, health, Israeli youth movement participation, sports, interests, hobbies, likes and dislikes, critical incidents, and personality types they identify and do not identify with. Secondly, they take five kinds of personality tests. They include:

a. A Thematic Apperception Test (TAT) that is specially contrived to deal with aviation bias, for example, an aircraft crash. This is an open-ended projective test. (Historically, they used Rorschach tests, but this practice had been terminated.)

b. Draw a Man tests.

c. Sentence completion tests.

d. The scales of the Eysenck personality test are used. These are the introvert/extrovert scale and the neuroticism scale.

e. The Taylor Manifest Anxiety scale.

Once these tests are completed, they are "worked up" by clinical psychologists and reviewed by a senior clinician or a psychiatrist. This individual, armed with all of the selection data gathered to this point, then interviews the candidate and assigns him a selection rating. At this stage, the selection rating is based 40% upon the candidate's personality, including the psychological work-up, 30% upon the perceptual/motor tests and 30% upon background variables (the predictive power of these tests was described as "modest" with respect to predicting success in pilot training).

Those accepted for pilot training skip the normal basic training given to others entering the Israeli Army and go directly to a 10-day "tent city" testing program which employs a new team of research scientists and pilots. During this period, candidates live in tents and are subjected to rigorous environmental stress. One complete day is spent in a field test involving obstacles and group activities. The pilot candidates are constantly observed by teams of pilots and sociologists. At the end of this period, a new selection rating is generated involving the following domains: (1) general motivation, (2) officer training field tests, and (3) two sociometric scales called the

"pilot" scale and the "friend" scale. These ratings are combined with the candidates' earlier selection ratings, and a final decision is made on each candidate.

The general philosophy preceding the 10 day testing period has been to keep the selection standards relatively modest. However, at the conclusion of the 10 day testing program, roughly 50% of the candidates are washed out and returned to other Army activities (Brown, 1976).

The Israeli selection specialist commented on a number of the selection domains that we thought might be potentially important for predicting combat effectiveness. His comments are shown in Figure 3.5-2 with respect to the domains of intelligence, physical and mental health, risk taking, personality, motivation, aggressiveness, courage, stress behavior, leadership, tactical judgement, and decision making. According to Brown (1976), the Israeli selection continues in the two-year pilot training program. After nine flights in the first four month course, about 20% of the candidates are rejected.[3] The 80% surviving that cut go on to four months of infantry training. During the first eight months, an informal selection process takes place so that the most promising students enter the fighter pilot program, the second group of students trains for helicopters, and the remaining students enter navigator training. During primary and basic flight training, in which another 10% of those who started training are eliminated, two separate lines of cadets are developed. One is that of the career officer and the other is for sergeant-pilots who serve for a period of only a few years. Following basic flight training, the pilots proceed through advanced training. Brown (1976) notes that all of the fighter pilots spend at least eighteen months flying the A-4 before being selected to transition

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- General intelligence. This is covered in the early stage of testing using the Raven and Otis instruments. Interestingly, it has been found that after that stage it is of no predictive power.
- Physical health. Until 1973 extremely high physical health medical standards were imposed upon the aviation community. Post '73 standards have been relaxed. For example, back seat F-4 personnel may now wear glasses.
- Mental Health. The clinical approach is used in the early testing program and not formally looked at again. Life inventory questions are also used during early testing which, in some cases, tap mental health. These factors may enter during later selection periods, particularly where instructor pilots are rating the candidates inasmuch as they are thought to prefer a certain stereotype. For example, many pilots generally prefer candidates from kibbutzim.
- Risk taking. The Israelis have never investigated this domain.
- Personality. Israeli testing continues throughout flight school where weekly meetings are held to discuss marginal candidates. At this point in time it is felt that the pilots are strongly influenced by the candidate's personality, perhaps even more than his flight skills.
- Motivation. This has never been a problem. Everyone making it to pilot training is considered very highly motivated. Those who are not strongly motivated are thought to take themselves out of the program early on. Motivation is a group motivational phenomena in Israel as opposed to more individualistic motivation in the United States.
- Aggressiveness and determination. These are never measured formally. However, they are considered informally in flight school. The same comments could be made for our determination domain.
- Courage. This is taken for granted but reflected only in a man's ultimate combat performance. Since Israeli conflicts, until the 1973 period, were considered a walk over, courage was never raised as an issue. With the increase in effective SAM sites during the 1973 operation this has become an issue. While air combat maneuvering ranges provided the ultimate surrogate combat environment, these were not effective tests of courage.
- Stress. Behavior under stress is tested during the ten day testing period and formal observers are used.
- Leadership. Leadership is one of the items considered in the peer rating occuring at the end of the ten day testing period. The pilot scale of this peer rating instrument is the best predictor of success in flight school.
- Tactical Judgement. This has never been assessed.
- Decision Making. Preliminary research has been going on for over three years in the general area of information processing and measures of attention.

FIGURE 3.5-2 THIS FIGURE SHOWS AN ISRAELI SELECTION SPECIALIST'S COMMENTS ON TWELVE POTENTIAL PREDICTORS OF PILOT COMBAT EFFECTIVENESS

[3]The Israelis' selection specialist regarded this as somewhat inefficient and would eventually hope to assign pilots directly to fighters, transports or other aircraft at the end of the preceding 10 day testing period.

into the F-4, Kfir, or Dassault-Breguet Mirage.[4]

If a pilot should attend the university, he must fly with his operational squadron as frequently as practicable, about once a week. Israeli squadron life also fosters combat effectiveness. It appears to be patterned somewhat after the RAF, inasmuch as the squadron forms a work/home social subculture complete in itself with very high inter- and intra-squadron competition being the rule.

3.5.2 The World War II German Program - A review of the German pilot selection program of World War II, is contained in an article by Fitts (1946). This subsection is based upon that report.

In 1939, the first year of existence of the Luftwaffe, the German Air Forces testing program was expanded (Fitts, 1946). This program was continued until February of 1942 when the entire selection program was discontinued at the order of Reichsmarshal Goering. After that, recruiting officers and medical examiners performed selection and classification duties. Selection tests were given at three types of testing centers, recruiting centers for Air Force Officers, recruiting and demobilizing centers, and regimental testing centers. These are briefly described in Figure 3.5-3.

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- Recruiting Centers for Air Forces Officers. Centers in Berlin, Hanover, Munich, and Vienna gave examinations to boys of school age who wanted to become officers in the German Air Forces. Emphasis was on testing for officer quality, but special aptitude tests for aircrew, antiaircraft, and communications assignments were given also.

- Recruiting and Demobilizing Centers. During most of the war there were nine Air Districts in Germany, and each had a center where both military and civilian volunteers for assignment as specialists in the Air Forces could be given medical and psychological examinations. A comprehensive examination formed the basis for decisions concerning selection and recommendations as to classification for enlisted pilot, bombardier, navigator, gunner, mechanic, antiaircraft, communications or paratrooper training.

- Regimental Testing Centers. Soon after the beginning of the war, psychologists were assigned to each of the regiments in the Air Forces where basic military training was given. While at these training regiments, individuals who had been drafted into military service were tested for the first time, and volunteers who had been tested at another center often were re-examined. Final classification was accomplished at this time. Authority for assignment of personnel rested with the regimental commanders, however, and not with the psychologists.

FIGURE 3.5-3 THIS FIGURE SHOWS THE THREE TYPES OF GERMAN TESTING CENTERS FOR PILOT SELECTION (FITTS, 1946, PP. 152-153)

Noting that the typical post World War I German believed that the intangible aspects of character were more important than aptitude or skill, Fitts (1946) indicated that the clinical assessment of leadership, character, and personality was the major purpose of the psychological examination. No standard battery of tests was used, but Fitts (1946) was able to classify the tests into five basic categories: Special aptitude tests, tests of sensory-motor coordination, tests of character and leadership, tests of perceptual ability, and tests of intelligence and judgment. These are described briefly in Figure 3.5-4.

According to Fitts (1946), the Germans did not validate their tests. This was probably due to the non-quantitative methods which were used. The non-quantitative information available was not amenable to statistical analysis. An indirect effect of this shortcoming was the failure to improve pilot selection procedures during the war. The selection of pilots in 1942 was apparently not substantially different from the selection of ground officers in the 1920s (Fitts, 1946).

Summarizing their World War II program, Fitts (1946) said:

> "...the points of view and methods of German psychologists were found to be quite different from those of most applied psychologists in the United States. Extensive use was made of tests, but for the most part psychologists disregarded exact test scores and relied instead on their clinical judgment. The concepts of objectivity, standardization, reliability, and validity were almost entirely lacking. No results of studies comparing agreement between different examiners or studies relating examination findings to subsequent success or failure in

[4] These groups are small and during this year, virtually every pilot has an opportunity to fly against two or three of the very best air-to-air combat pilots in Israel. At the end of this period selection of assignment to air-to-air combat wings is, literally, on an individual basis. According to our Israeli colleague, selection standards are so high at this juncture that in certain periods no pilots are selected.

- Special Aptitude Tests. Special tests were used for selecting height-finder, sound-detector, and radio operators. Code learning ability was measured by an individual test in which the candidate attempted to reproduce code sounds heard through earphones. In a group test of code aptitude, recorded on phonograph records, candidates judged whether paired code sounds were the same or different.

- Tests of Sensori-Motor Coordination. Several tests were used to measure coordination and speed of reaction. These tests were used in predicting capacity for learning skills and also in studying personality characteristics. Included in the group was a test in which the candidate mainipulated a stick and rudder in response to light signals from three separate rows of lights (similar to the S. A. M. Complex Coordination Test, the original model of which was developed at the AAF School of Aviation Medicine in 1928); a test in which the candidate responded to visual and auditory signals while strapped to the outer rim of a large rotating vertical wheel; a test which required balancing on an unstable platform; and a series of sports tests including running, jumping, chinning, putting the shot, and negotiating an obstacle course. The Complex Reaction test is typical of this group. It was considered by most of the psychologists who were interviewed to be their best apparatus test although no evidence on this point was given. It was designed originally by Dr. Rieffert to measure ability to react with both hands and feet to a variety of visual and auditory signals. However, it was believed that the complexity of the task and rapidity of the fixed pace also made it a valuable test of temperament. On a large screen could be presented automatically one of five visual stimuli which varied both in color and form. Either a bell or a buzzer also could be sounded. The candidate was seated 4 meters from the screen and operated three large hand levers and two foot pedals in response to a series of 330 visual and auditory stimuli which were presented in a random order and at a predetermined rate during a period of eight minutes. Scoring was in terms of the number of correct responses and observations were made of general behavior during the series.

- Tests of Character and Leadership. Observations concerning personality characteristics were made throughout the examination, but several situations were designed especially to test character and leadership ability. Character tests included the analysis of speech, voice and facial expression, and observation of behavior as the candidate neared physical exhaustion on an obstacle course which was impossible of completion. Leadership tests included a group discussion in which several candidates participated, and an orders test in which candidates were required to take charge of several assistants and direct them in the accomplishment of a practical task. The orders test resembled closely procedures adopted subsequently by British War Office Selection Boards and used by the OSS in the United States. The method used in handwriting analysis is typical of the group of character analysis procedures. A great deal of attention was given to the study of handwriting. Most of the psychologists who were interviewed believed that the method was of considerable value, although admitting that techniques used in analysis were subjective and unstandardized. It was generally believed that handwriting analysis also revealed intellectual ability, temperament, feeling and mood, maturity and spiritual qualities.

- Tests of Perceptual Ability. Many German theories assumed that individuals could be typed on the basis of characteristic ways of perceiving. Most perceptual tests were designed, therefore, to indicate character and personality structure as well as speed and accuracy of perception. A candidate might be required to adjust a movable rod until it was judged to be in the same vertical plane as two fixed hairs, or adjust a vertical line while wearing special lenses in front of his eyes, or observe a five-minute motion picture sequence and then describe what he had seen; or to orient himself by use of visual and auditory cues which were in conflict.

- Tests of Intelligence and Judgment. Several tests were used to provide measures of verbal, numerical, memory, and reasoning ability. Candidates might be required to write twenty-minute essays; to solve mental and written arithmetic problems; to listen as a passage was read and later recall key words from it; or to look at a motion picture or a drawing of a complex mechanical device and then write a description of how the apparatus worked. No objective type vocabulary or reading comprehension tests were used. The Test of Practical Judgment is characteristic of tests in this group. Items in a printed booklet described problems requiring practical judgment for their solution. For example, one item described the problem facing an officer who had to reach an objective, and who could choose one of three possible routes for his troops; a direct route which was under enemy fire; a longer route across a partially damaged bridge; and a route across a lake on which there were no boats. The candidate wrote accounts of what he would do in each situation, giving reasons for his choices of action. In scoring the test, no single choice was considered correct, but the reasons given for choosing a particular solution were studied for indications of planning ability and good judgment.

FIGURE 3.5-4 THIS FIGURE GIVES AN OVERVIEW OF PILOT SELECTION TESTS USED BY THE GERMANS DURING WORLD WAR II (FITTS, 1946, PP. 154–155)

training and combat were located. The statistical techniques which a psychologist in the United States would consider essential for the analysis of group data apparently were unknown to the majority of German psychologists. . .

"The lasting scientific contribution of German aviation psychologists appears at present to be quite small. The value of their characterological examination techniques, and the soundness of their theories concerning the total personality will be determined only through subsequent research. In summary, it can be said that psychology, insofar as it continued to be a liberal science of the individual, did not prosper under the social philosophy and political control which existed in Germany prior to, and during World War II." (pp.159-160).

3.5.3 The World War II Japanese Program - A review of the Japanese pilot selection program in World War II is contained in an article by Geldard and Harris (1946). This brief review is based upon that article.

The Japanese had interest in aviation psychology as early as 1918, and this interest was manifested in the establishment of their Army Air Force psychological research laboratory in 1935 (Geldard and Harris, 1946). Numerous tests, both written and psychomotor, were developed in the laboratory and some unusual test ideas also emerged. For example, an orientation test was tried in which the subject was shackled to a large hoop and required to perform various identification tasks while being rotated.

Japanese pilot candidates were tested at the Aviation Fitness Testing Unit which was a central testing facility. Like the United States, psychological testing was organized under the medical department. The testing program included group tests of intelligence, numerical ability and rhythm perception; and individual tests of psychomotor and verbal ability. The verbal test was actually an interview which used a biographical data blank as a starting point. Figure 3.5.5 presents an overview of the tests used by the Japanese Army Air Forces during World War II.

Unfortunately, the validity data for the Japanese Army Air Forces tests were destroyed. Interviews with Japanese psychologists indicated that the validity coefficients ranged from .30 to .65 (Geldard and Harris, 1946). The criterion used was rank order in the class at the conclusion of training. Those interviewed (Geldard and Harris, 1946) indicated that the criterion was too unreliable for the coefficients to be meaningful.

The Japanese Naval Air Force also conducted psychological testing in conjunction with the

Intelligence Tests

These tests existed in five forms, differing in their degree of difficulty. All contained the following six parts, however:

a. Directions. Simple instructions were to be followed, e.g., "You will see circles from 1 to 5 arranged in a circular pattern like a plum blossom. When I say 'Begin' draw a straight line connecting Circle 1 and Circle 3, and a straight line connecting Circle 5 and Circle 2." Ten different sets of instructions comprised this section.

b. Digit Comparison. Two columns of four-digit numbers were given; the pairs were to be judged as "same" or "different", thus:

7935 7935 (same)
4013 4913 (different)

This was a test of clerical speed and accuracy involving 50 pairs of numbers, four to nine digits in length.

c. Hidden Figures. Simple geometric forms, "hidden" in a much more complex one, were to be found and identified by appropriate numbering. This was essentially a paper formboard. There were 15 forms to be located.

d. Substitution. Digits were to be substituted for geometrical forms in a long sequence of the latter, eight series of 40 symbols each being presented.

e. Reasoning. A sequence of logically related digits was to be completed. e.g, 1, 2, 4, 8, –, 32. Twenty problems of this type were included in this "inductive reasoning" test.

f. Arithmetic Reasoning. A set of 10 problems, 4 multiple choice answers being supplied in each, were to be solved. Certain of the items made rather less demand on reasoning processes than upon possession of common bits of information.

Scoring. Total scores on the intelligence test would range between –16 and +21 after appropriate conversion of all six parts.

Psychomotor Tests

Motor Coordination Test "A"

This test was essentially a "mirror drawing-eye-hand-foot coordination test." A movable plate, carrying a record form with an irregular line path, could be moved to and fro by appropriate motions of a "rudder"; an ink-writing stylus, controlled by a "stick", could trace left-right deviations of the path. Looking in the mirror, and with hands and feet screened, the line was to be traced as accurately and rapidly as possible. "This is a test of adaptability, embarrassment, and judgment." A tracking of the combined responses of hand and foot could now be compared with the true path. Accuracy was not objectively scored but five "standard patterns" served as sources of comparison. Thus the scoring procedure used in handwriting and similar scales was used, it admittedly having a large subjective element, but judged to be sufficiently accurate for the purpose at hand.

Motor Coordination Test "B"

This test involved a horizontal drum, viewed through a mirror, the drum, rotating toward the subject at a rate of one revolution per minute. A paper on the drum had two irregular but parallel lines on it which were to be followed with ink-writing styli actuated by stick and rudder controls. Paper speed past the recording points was 1 cm /sec. Lateral adjustments of the "stick" permitted tracing one of the lines; the rudder" traced the other. A practice period involving two revolutions of the drum was allowed, then a single scored trial of one revolution (60 cm. record) was given. Any obvious clumsiness in manipulation led to a repetition of the test. If the clumsiness remained, the fact was noted on the record sheet under "Remarks." Any "remark" had an important bearing on the final decision.

Caclulations Test ("Test of Working Ability").

The "pattern" of performance, as judged by the work profile, was compared with those for "normal", "subnormal", "middle", "unstable", and "pathological" types. The average total number of digit pairs completed also contributed to a complex score, partially determined also by the amount of variability from row to row and the general work decrement. An "introspective report", consisting of checked answers to 24 questions, inquired into feelings and attitudes prior to, during, and after the examination. This test was regarded by its users to be a "diagnostic test of character" and, as such, was thus largely clinical in spirit and interpretation. Successive pairs of digits arranged in long rows were to be added and the integer in the unit column of each sum written down. The examinee worked continuously for one minute when he was stopped and directed to the next row of digits. Accuracy of the result was less important than total "mental work" performed which, in turn, was regarded as less significant than the total "pattern of response" throughout the entire test. Fifteen rows were to be completed, a five minute rest period was interposed, then 10 more rows were worked in the same fashion.

Auditory Perception of Rhythm Test.

This test was given in two parts. In the first, four groupings of sounds: A = .—; B = —..; C =—.—.; D =—... were presented in mixed order. The examinee simply identified each and wrote down the appropriate symbol: A, B, C, or D. The sounds were reproduced from a gramaphone record through a loud speaker; individual ear phones were not used. In the second part of the test 20 groups of three word sounds each were presented, the task being to indicate whether one sound, different from the remaining two, came first, second, or third in the sequence.

The test was designated by its users the "communications" or "code" test and was originally devised with radio communications in mind. It was used in the selection of all aircrew and certain ground personnel, however.

FIGURE 3.5-5 THIS FIGURE GIVES AN OVERVIEW OF SELECTION TESTS USED BY THE JAPANESE ARMY AIR FORCE DURING WORLD WAR II (GELDARD AND HARRIS, 1946, PP. 207–208)

medical examination. The types of tests used were similar to those used by the Japanese Army Air Forces, but there was apparently greater emphasis placed on the psychomotor tests in the Navy group. Figure 3.5-6 presents an overview of the factors used by the Japanese Naval Air Force during World War II.

There has been great interest in the kamikaze pilot over the years. From the research of Geldard and Harris (1946), it appears that very little selection per se was used for this group. A very interesting quote from Geldard and Harris serves to point out many flaws in such a system and to describe this unique military phenomenon.

> ". . . kamikaze pilots were not selected, in the usual sense, at all. The army policy was to force applications by creating a 'spiritual atmosphere,' offering unusual rewards, and by indicating by rational argument that military necessity required a large number of applicants. At the beginning applicants were prompted by the highest patriotic motives; later a poor type of 'show-off' applied. The actual decision to become a kamikaze pilot was made in a kind of 'father confessor' situation, held privately between the applicant and his commanding officer. Upon being 'converted' the candidate was given very special privileges: (1) he could go on leave immediately (a very rare reward in the Japanese Army); (2) he was given special foods - anything he wished; (3) he was encouraged to indulge himself sexually; (4) he could, within limits, choose the time of his death, i.e., when his mission was to take place. Completely untrained pilots were never used, contrary to rumor. Some had had as many as 3000 flying hours. Late in the war a few had had as little as 20 hours of training, but this was very exceptional and at a time when the fully trained pilot, ready for combat, might have had less than 100 hours total flying time.
>
> 9—1021

Intelligence Test.

This test had twelve parts as follows: (1) Mazes; (2) Cube counting; (3) Pattern test; (4) Symbol-digit substitution; (5) Accuracy with digits (same-different); (6) Simple addition; (7) Inductive reasoning (geometrical forms); (8) Inductive reasoning (digit series); (9) Cancellation of geometrical forms; (10) Figure completion after rotation of figure; (11) Identification of relative parts of distorted figures; (12) Following directions.

Kraepelin-Uchida Mental Addition Test.

This test was, in all particulars, identical with the "Calculations Test" used by the JAAF and described in Figure 3.5-5.

"Motion Control" Test.

In this apparatus an artificial horizon, viewed through a window, was made to oscillate erratically by a motor driven cam. A "stick", free to move laterally, was joined by a pulley system to the cam mechanism and appropriate right-left movements would correct for the tipping of the horizon. The time in which the horizon was held level, in a continuous pursuit performance, was measured with an electric chronometer.

"Three Pointer" Test.

This was also a pursuit test. Three differently colored pointers, moving about a common axis, were required to be kept in coincidence. A black pointer, driven by an electric motor, made simple reciprocating pendular motions. A red pointer, controlled by a "rudder", and a white one, moved by a "stick", were to follow the black pointer. The time in which all three were in coincidence was measured by an electric timer.

"Judgment Coordination" Test.

A motor-driven turntable, disposed horizontally, had painted on its periphery a series of arrows, some pointing centripetally, others centrifugally. Two needles, actuated by a single wheel which could be turned clockwise or counterclockwise, were suspended over the near edge of the disc. Movements of the wheel caused the needles to move to the right or left without changing their spacing. The task was to make the needle points pass always behind the arrows and without touching the edge of the disc. Errors were recorded by an electric counter.

"Selective Reaction" Test.

On a sloping panel there appeared, through a window, a row of six arrows. Each arrow could point in any of eight directions. The three on the right, together with a "guide" arrow which appeared in a smaller window above them, were to be reacted to with the right hand. Whenever any two of the three had the same indicated direction as the guide arrow a key was to be pressed. The same arrangement obtained for the left side of the apparatus, a second key being supplied for the left hand. All arrows changed direction once each second. Errors were counted electrically.

"Memory of Speed" Test.

An endless belt, 60 cm. wide, having alternate black and white stripes painted on it, was driven at a constant and predetermined rate. The examinee was to view the moving field and "memorize" it. The field speed was then changed and the subject was required to adjust it, by turning a control knob, until the remembered speed was reestablished. The extent of the error of setting was measured on a calibrated scale.

"Figure Regeneration" Test.

A series of geometrical figures, connected in a single sequence, passed by a window in a box. The examinee was to view the entire sequence, "integrate" it, then reproduce the whole figure by drawing. This test, inspired by Gestalt considerations, also made its way into the USAAF experimental program in motion picture testing.

FIGURE 3.5-6 THIS FIGURE GIVES AN OVERVIEW OF THE SELECTION TESTS USED BY THE JAPANESE NAVAL AIR FORCE DURING WORLD WAR II (GELDARD AND HARRIS, 1946, PP. 215–216)

"The morale of special attack pilots was bad, on the average. After the 'feast,' the kamikaze pilot was likely to lose much of his fervor and many made all kinds of excuses to get out of the final death mission. One is known to have burned his plane on the night before his scheduled takeoff. In general, the planes used were very inferior ones, naturally, and the pilots came to mistrust them. 'Good results cannot come out of despair' and the average effectiveness of the special attack pilot in guiding his plane to the target was said to be very low. The poor morale of this group led Mr. Mochizuki, who was making a special study of this matter for Koku Hombu, the Air Headquarters, to recommend to the Minister of War that the entire venture be dropped. Humanitarian considerations were not involved in this recommendation - 'That had all been settled at the beginning and there was no point in raising the question' - but sheer military ineffectiveness coming out of atrocious morale was the reason for the recommendation. Poor morale was not an uncommon phenomenon in the Japanese Army Air Force and was traceable to more causes than mechanical inefficiency of the planes." (pp. 211-212)

3.5.4 Summary - Several important items can be gleaned from the review of foreign selection programs. The German selection program in World War II worked moderately well but was dropped early in the war. Their emphasis on the intangible aspects of character at the expense of aptitude or skill factors limited the program. The Japanese had a well conceived testing program, but relied upon a criterion with low reliability (class rank in a training course).

The Israelis have a unique testing and selection program which, in many ways, goes beyond other programs. They include a ten day "tent city" test program, continue the selection process through training, and have less stringent educational prerequisites. Several selection factors which are not assessed in the U.S. military aviation community are evaluated in the Israeli program. Most notable are stress tolerance and the broad set of personality factors tested in a group performance environment.

3.6 PILOT INPUTS TO THE DEVELOPMENT OF HYPOTHESES CONCERNING THE CHARACTERISTICS OF THE ACE

In addition to technical sources of information concerning the characteristics of combat effective pilots, both direct and indirect sources of pilot opinion concerning combat effectiveness were investigated. It was felt that these pilot opinions would add critical insights into the complex problem of combat effectiveness. Four approaches, three direct and one indirect, were used to gather this information. These consisted of a review of popular literature describing fighter pilots in American, German and Japanese air forces during World War II and the American Air Force during the Korean War. The three direct sources of pilot opinion were derived from questionnaires returned to us by 373 pilots (and described in Section 2.0). The responses to three items on that questionnaire constitute the pilot inputs to this section. The first item, "From your personal experiences, do you recall any event which illustrates the qualities required for an ace," is an open-ended question, and extensive responses were received. In the second item, pilots were asked to rate a number of categories of personal attributes with respect to their importance in becoming an ace. The third item concerned flying, perceptual and judgmental skills and abilities which would distinguish an effective from a non-effective fighter pilot. An analysis of these responses provided much useful information regarding the critical personality characteristics and the skills necessary to make up the combat effective pilot. These responses also provided one of the bases for our analysis of the importance of the various selection factors identified in the technical combat literature.

3.6.1 Pilot Inputs from the Popular Literature- Hundreds of books have been written describing ace fighter pilots. Unfortunately, most of these books and stories are fictionalized descriptions of a somewhat larger than life heroic figure. From this literature, only a few books emerge as being reasonably accurate accounts of the pilots themselves and their actions. These books are typically either biographical, autobiographical or based on interviews with the pilots. To sample this literature, we reviewed 14 books directly concerned with descriptions of aces from the U.S., Germany, and Japan during World War II as well as material available on the American aces from Korea. From this group, those books written by Col. R. F. Tolliver and T. J. Constable, E. H. Sims, G. Gurney, and Saburo Saki were especially useful. Despite the basic historical validity of these books, the style of writing of the authors tends to romanticize the descriptions of the fighter pilots. Attempts were made to abstract from these books accurate descriptive passages which would illustrate the characteristics of the greatest ace fighter pilots, although specific characteristics related to the ace fighter pilot were difficult to find within the context of the writing. Figure 3.6-1 illustrates the results of this review.

From Figure 3.6-1, it is apparent that aggressiveness, the ability to spot the enemy, the courage to attack, and skill in both gunnery and handling the aircraft are considered important or at least notable characteristics of the ace. An excellent overall summary description of these characteristics was found in G. Gurney's (1961) book Five Down and Glory;

> "Thus we have the creature, the ace. He was neither always young nor always old: age was no criterion. Nor did size, nor height, nor physical build matter. He was not necessarily an extrovert nor an introvert; a braggart nor a shy recluse. But though there were many things the ace was not, there were several things he seemed always to be.
>
> "The ace flew aggressively and always pressed his attack. He was not necessarily reckless nor foolhardy, but he was daring and a fighter. He loved to fly and knew his business when he had the flying machine strapped on by the safety belt. He was constantly on the alert for the enemy and his experienced eyes were able to catch that flicker of motion, that flashing speck on the horizon, that almost unseen movement that was sometimes the only indication that an enemy was sharing the same

RAOUL LUFBERY (17 KILLS, WW I, USA)	"A PILOT WHOSE ATTACK WAS LIKE LIGHTNING, WHOSE MARKSMANSHIP WAS UNCANNY AND WHOSE NERVE WAS NEVER SHAKEN." (GURNEY, 1961, p. 16)
EDWARD RICKENBACKER (26 KILLS, WW I, USA)	RICKENBACKER HAD PATIENCE ACQUIRED FROM HIS RACING-CAR DAYS. HE WAS DARING AND FEARLESS, BUT NEVER RECKLESS. (GURNEY, 1961, p. 31)
FRANK LUKE (18 KILLS, WW I, USA)	FRANK WAS A QUIET BOY FROM THE FRONTIER COUNTRY, A COLLEGE GRADUATE AND A CITIZEN-SOLDIER, WHO LOVED TO FLY AND LOVED TO FIGHT. HE DIDN'T CARE MUCH FOR THE REGIMENTATION OF MILITARY LIFE AND MORE OFTEN THAN NOT HE WOULD WANDER FROM A FORMATION TO SEARCH OUT THE ENEMY ALONE. (GURNEY, 1961, p. 29)
RICHARD I. BONG (40 KILLS, WW II, USA)	ALTHOUGH MORE OR LESS AN INTROVERT ON THE GROUND, HE WAS THE EXACT OPPOSITE IN THE AIR. ALWAYS EAGER FOR ACTION, HE TOOK HIS P-38 INTO ANY ENEMY FORMATION HE COULD FIND REGARDLESS OF THE ODDS. WHEN HIS FELLOW PILOTS WERE IN TROUBLE, BONG SPED TO THE RESUCE. (HESS, 1968, p. 28)
THOMAS B. MCGUIRE (38 KILLS, WW II, USA)	"ON INDIVIDUAL COMBAT TACTICS, AGGRESSIVENESS IS THE KEYNOTE OF SUCCESS. A FIGHTER PILOT MUST BE AGGRESSIVE. THE ENEMY ON THE DEFENSIVE GIVES YOU THE ADVANTAGE, AS HE IS TRYING TO EVADE YOU, AND NOT TO SHOOT YOU DOWN." (GURNEY, 1961, p. 106)
GERALD R. JOHNSON (22 KILLS, WW II, USA)	"DURING MY EXPERIENCES IN OPERATING AGAINST THE JAPANESE AIR FORCE THERE HAVE BEEN EVIDENT CERTAIN CHARACTERISTICS AND TRAITS PECULIAR TO THE JAPANESE AS AIRMEN. A KNOWLEDGE AND AN UNDERSTANDING OF THESE CHARACTERISTICS IS NECESSARY IN ORDER TO EFFECTIVELY COMBAT THE JAP...IN ORDER TO EFFECTIVELY ATTACK THE JAP, YOU MUST SEE HIM FIRST." (GURNEY, 1961, p. 108)
FRANCIS S. GABRESKI (34.5 KILLS, WW II KOREA, USA)	HIS DAYS WITH THE POLES DIDN'T RESULT IN ANY VICTORIES, BUT FROM THEM HE DID GAIN A DETERMINATION AND AGGRESSIVENESS THAT WAS TO MAKE HIM ONE OF THE GREAT FIGHTER PILOTS OF THE WAR. FROM THESE MEN HE ALSO LEARNED THE TACTIC OF CLOSING WITH THE ENEMY TO THE POINT THAT YOU JUST COULDN'T MISS. (HESS, 1968, p. 29)
JOSEPH MCCONNELL JR. (16 KILLS, KOREA, USA)	"YOU HAVE TO GO LOOKING FOR THEM. SOMETIMES EVEN THIS DOESN'T HELP. I KNOW OF PILOTS WHO HAVE FLOWN 100 MISSIONS AND HAVEN'T BRUSHED WITH THE MIGs ONCE." (GURNEY, 1961, p. 205)
ERICH HARTMANN (351 KILLS, WW II, GERMANY)	...AS WELL AS BY INSTINCT AND TRAINING, A FIGHTER. HIS PHYSICAL AND MENTAL RESILIENCE WERE SUCH THAT HE ENDURED WITHOUT FATIGUE THE CONSTANT GRIND OF AERIAL COMBAT FROM THE FALL OF 1942 UNTIL THE END OF MAY 1945...HARTMANN'S SUCCESS WAS DUE TO THE WAY HE DROVE HOME HIS ATTACKS. THEY WERE POINT-BLANK, LIKE THE MAN. (TOLIVER AND CONSTABLE, 1970, p. 111)
GERHARD BARKHORN (301 KILLS, WW II, GERMANY)	"HE IS MY CHOICE OF ALL THE SECOND WORLD WAR FIGHTER PILOTS. STEADY, RELIABLE, A GOOD LEADER, HE NEVER MADE A VICTORY CLAIM THAT WASN'T CONFIRMED." (TOLIVER AND CONSTABLE, 1970, p. 97)
GUENTHER RALL (275 KILLS, WW II, GERMANY)	A MAN OF SURPASSING WILL POWER AND COURAGE.... HE WAS PERHAPS THE KEENEST COMPETITOR AMONG ALL THE TOP-SCORING GERMAN PILOTS DURING THE WAR. (TOLIVER AND CONSTABLE, 1970, p. 99)
WERNER MOELDERS (115 KILLS, WW II, GERMANY)	"WERNER MOELDERS WAS A VERY WELL-EDUCATED AND A HIGHLY INTELLIGENT MAN WITH AN EXCEPTIONALLY GOOD CHARACTER. HIS CHARACTER WAS SUCH THAT IT GUARANTEED EVERYTHING ELSE ABOUT HIM. HE HAD A DIRECT LINE OF THOUGHT, WAS BRILLIANTLY ANALYTICAL, AND HE WAS ESPECIALLY A MAN WITH GOOD LEADERSHIP." (CONSTABLE AND TOLIVER, 1968, p. 65)
HANS-JOACHIM MARSEILLE (158 KILLS, WW II, GERMANY)	NO ONE WHO SAW HIM SHOOT IN THE AIR WILL EVER FORGET HIS DEADLY PRECISION. MARSEILLE WAS MUCH MORE, HOWEVER, THAN JUST A SUPERLATIVE MARKSMAN. SINCE HIS SHAKY BEGINNING AS A CADET PILOT, HE HAD DEVELOPED AN AEROBATIC ABILITY SO PRONOUNCED THAT HE COULD THRILL EVEN VETERAN GERMAN ACES WITH HIS FLYING. MARSEILLE'S PORTFOLIO OF TALENTS ALSO INCLUDED EAGLE EYESIGHT, FEARLESSNESS, AND AN AGGRESSIVE SPIRIT IN THE AIR THAT FREQUENTLY UNNERVED HIS FOES. TO SPEAK OF AN "AGGRESSIVE SPIRIT" MAY SEEM LIKE AN ABSTRACTION. COMBAT PILOTS KNOW OTHERWISE. (CONSTABLE AND TOLIVER, 1968, pp. 102-103)
ALEXANDER POKRYSHKIN (59 KILLS, WW II, RUSSIA)	THE UNDAUNTED POKRYSHKIN SOON PROVED HIMSELF TO BE MORE THAN JUST AN UPSTART MECHANIC. HIS FINE PILOTING SKILL WAS UNDENIABLE, AND HIS DETAILED KNOWLEDGE OF AIRCRAFT CONSTRUCTION EXCEEDED THAT OF HIS FELLOWS...WROTE THE ELATED POKRYSHKIN: "SUCCESS DEPENDS ON FIRING FROM CLOSE RANGE." TOLIVER AND CONSTABLE, 1970, pp. 125-126)
HIROYOSHI NISHIZAWA (104 KILLS, WW II, JAPAN)	EVEN HIS EYESIGHT WAS UNUSUAL. WHERE WE COULD SEE ONLY SKY, NISHIZAWA, WITH ALMOST SUPERNATURAL VISION, COULD CATCH THE SPECKS OF ENEMY PLANES STILL INVISIBLE TO US. NEVER IN HIS LONG AND BRILLIANT CAREER AS A WARRIOR OF THE SKIES WAS THIS MAN CAUGHT UNAWARE BY THE ENEMY...HE LIVED AND BREATHED ONLY TO FLY, AND HE FLEW FOR TWO THINGS; THE JOY WHICH COMES WITH THE OWNERSHIP OF THAT STRANGE AND WONDERFUL WORLD IN THE SKY, AND TO FIGHT. (SAKI, 1957, p. 84)

NOTE: QUOTATION MARKS INDICATE EITHER THE ACE'S OWN OPINION OR THE OPINION OF A CONTEMPORARY REGARDING THE ACE. OTHER DESCRIPTIONS WERE TAKEN DIRECTLY FROM THE INDICATED REFERENCES.

FIGURE 3.6-1 CHARACTERISTICS OF THE GREATEST FIGHTER PILOTS

> sky. In some cases aces have been able to run up an impressive number of victories because of their exceptional shooting abilities, but while this ability often made a difference in final totals, it seldom, alone, made a flyer an ace. The ace understood his business, learned from his own experience and from that of others, carefully employing those tactics which put to greatest advantage his fighting vehicle. With this combination of fighting attributes the ace seized the advantage to sweep the enemy before him." (p. 206)

The review of popular literature provided a general background and some insights into what goes into making an ace. The popular literature is, however, a secondary source of these descriptions, written to entertain rather than analyze the profile of an ace. Alternative information sources were therefore developed.

3.6.2 Characteristics and Attributes of the Ace Fighter Pilot - Inputs from 100 Aces - Another source of evidence concerning the characteristics and attributes of the combat effective fighter pilot can be developed by asking what ace fighter pilots think about this issue. As part of our questionnaire effort, we asked a large number of fighter pilots the following question, "From your personal experience, do you recall any event which illustrates the qualities required of an ace?" The pilots' responses are most interesting and are presented in Section 3.6.2.2. In order to draw a composite profile of the combat effective pilot from the response of aces, we selected the first 100 ace fighter respondents' answers and subjected them to an analysis.

3.6.2.1 Analysis of Ace Pilot Written Responses - One of the authors examined each of the first 100 substantive ace pilots' written responses and tabulated descriptive words and phrases, such as aggressiveness, cool head, etc. In all, he found some 140 different descriptor phrases with, of course, many descriptors repeated often (e.g., aggressiveness was the most common descriptor word and appeared explicitly in no less than 20 pilot responses). Rough categories were established from the 140 descriptive words, and the results are shown in Figure 3.6-1. In this figure, some 30 major categories are identified. Various descriptive words which seemed to fit in them are shown in smaller type face below each major descriptor word. This sort of analysis is admittedly crude; language by its very nature is imprecise. Additionally, the pilots were giving us spontaneous responses and, in some cases, illustrations of combat behavior. Nevertheless, we find this a fruitful way of generating working hypotheses which can later be subjected to more rigorous scientific examination.

Based on the descriptors shown in Figure 3.6-2, the fighter pilots feel that a combat effective fighter pilot must be extremely aggressive and have the self-confidence to search out opportunities to engage the enemy and fight him although outnumbered and forced to take risks. He must have adequate flying ability and aerial gunnery skills and be prepared to exploit the air battle with an understanding of his aircraft and its total performance capability, as well as an understanding of the enemy's aircraft and tactics. He and his wingman should enter the battle as a disciplined team.

The combat effective fighter pilot must also have motivation, determination, dedication, desire, instinct and deliberateness of attack. He must be unafraid and have the courage to close with the enemy and attack him at very close range. The ideal fighter pilot should be in good health. He should have excellent visual target acquisition ability, be alert, have fast reactions, have an awareness of the battle arena, have the ability to make quick decisions and to act upon them; he must work calmly under stress. Ideally, this man would also be a leader and highly professional in his conduct.

3.6.2.2 What Ace Fighter Pilots Told Us About the Qualities Required of an Ace - As part of our questionnaire effort, we asked a large number of fighter pilots the following question, "From your personal experience, do you recall any event which illustrates the qualities required of an ace?" The

AGGRESSIVE
- BE A TIGER
- HARD NOSED
- FORCE THE ATTACK
- MAINTAIN THE INITIATIVE
- SPIRIT TO TAKE THEM ON
- WILLINGNESS TO FIGHT
- (HAVE THE) SPIRIT OF ATTACK
- (ATTITUDE OF) HAVING THE ENEMY "CORNERED"
- (ATTITUDE OF) DESTROY, NOT SURVIVE

CONFIDENCE
- SELF CONFIDENCE
- (TO BE SUCCESSFUL)
- CONFIDENCE IN FIGHT
- CAN DO ANYTHING

MAKE OPPORTUNITY HAPPEN
- LOOKED HARD FOR THE ENEMY
- STAYED LONGER WITH STRAGLERS AND GOT MORE KILLS
- WHEN YOU CAN ATTACK – DO IT.

FIGHT AGAINST ODDS
- MOVE AGAINST ODDS
- CONTINUE AGAINST (ADVERSITY)
- DON'T CONSIDER (THE) ODDS
- GO – EVEN WHEN OUTNUMBERED

RISK TAKING
- TAKE ALL RISKS
- (MUST) STICK OUT HIS NECK (AT LEAST ON OCCASION)
- (BE A) CALCULATED RISK TAKER
- ONCE FIGHT STARTS – GO FULL BLOWER
- (MUST HAVE) WILLINGNESS TO TAKE CHANCES
- ONCE DECIDED – CHARGE IN
- ENJOY PERSONAL COMBAT
- NO CONCERN FOR PERSONAL SAFETY

FLIGHT ABILITY
- CONTROL OF AIRCRAFT
- KNOW YOUR JOB
- EXPERIENCE, TRAINING, PRACTICE

AERIAL GUNNERY
- BE A DAMN GOOD SHOT
- CLOSE IN ATTACK

BE PREPARED
- KNOWLEDGE OF YOUR AIRCRAFT
- KNOWLEDGE OF ENEMY
- PREPARED FOR FIGHT
- (BE) READY
- THINK WHERE (ENEMY) WILL BE
- LOOK AROUND
- NEVER CONCENTRATE TOO LONG

EXPLOIT
- TAKE ADVANTAGE OF THE ENEMY'S MISTAKES
- TAKE EVERY ADVANTAGE
- ATTACK WITH ADVANTAGE
- USE AIRCRAFT TO YOUR ADVANTAGE
- MANEUVER TO TAKE ADVANTAGE
- FIRE WITH SPEED TO REGAIN ALTITUDE

DISCIPLINED
- SELF DISCIPLINE
- AIR DISCIPLINE
- MILITARY DISCIPLINE

TEAM
- SYNERGISM OF LEADER AND WINGMAN TEAM
- CONFIDENCE AND TRUST IN TEAM

MOTIVATION
- DRIVE
- EAGER
- HUMILIATED IN AIR ONCE – NEVER AGAIN
- ANGER AT BEING JUMPED – KILLED ALL FOUR

DETERMINATION
- TO SUCCEED
- (TO) WORK HARDER THAN ANYBODY
- SEE YOUR JOB AND DO IT
- (TO) NEVER GIVE UP

DEDICATED
- TO CAUSE
- TO ATTACK
- TO COUNTRY
- TO PURPOSE
- TO ACHIEVE VICTORY
- PATRIOTIC
- LOYALTY (TO COUNTRY)
- CONSCIENCIOUS

DESIRE
- TO ACHIEVE
- TO ATTACK
- TO WIN
- TO ENGAGE (THE ENEMY)
- TO DO EVERYTHING TO WIN
- HAVE PURPOSE IN MIND
- DO IT BEST
- HAVE AMBITION

INSTINCT
- OF HUNTER
- OF KILLER
- INBORN
- FOR COMBAT

DELIBERATE
- ABOUT THE ATTACK
- CALCULATING
- POSITIONING

UNAFRAID
- NOT BE AFRAID
- AFRAID AS LITTLE AS POSSIBLE
- RESOLUTE

COURAGE
- GUTS
- TO ENGAGE THE ENEMY
- YET HAVE COMMON SENSE
- KNOW WHEN TO FIGHT ANOTHER DAY

CLOSE IN ATTACK
- NO DEFLECTION SHOOTING

GOOD HEALTH
- STAMINA
- PHYSICAL COORDINATION

VISUAL ABILITY
- TO SPOT THE ENEMY
- WIDE FIELD OF VIEW
- GOOD PERIPHERAL VISION
- SEE HIM BEFORE HE SEES YOU

ALERT
- ALERT THINKER
- QUICK AND SMART
- KEEN
- GOOD THINKING-PLANNING

FAST REACTIONS
- QUICK REACTION
- SPLIT SECOND DECISION

AWARENESS
- OF ALL AIRCRAFT IN THE BATTLE

FAST ABILITY TO DECIDE AND ACT
- NO HESITATION

STRESS
- THINK WELL UNDER STRESS
- CONCENTRATE UNDER STRESS
- HEAR AND THINK IN BATTLE

CALMNESS
- COOL HEAD
- (CALM) UNDER FIRE

LEADERSHIP
- BE A LEADER
- DON'T LOSE YOUR WINGMAN
- LOYALTY TO FRIENDS

PROFESSIONAL
- KEEP A SENSE OF HUMOR (PROPORTION?)
- NO GOODBYES – NO REGRETS

FIGURE 3.6-2 THIS FIGURE SHOWS A COMPOSITE OF THE CHARACTERISTICS AND ATTRIBUTES OF THE COMBAT EFFECTIVE FIGHTER PILOT. THIS COMPOSITE WAS ASSEMBLED FROM THE WRITTEN COMMENTS OF 100 AMERICAN ACE FIGHTER PILOTS.

quotes from 70 of the first 100 aces who responded to this question are presented in this section. The reader is invited to review them and then reread the thumbnail description of the ace that was presented in Section 3.6.2.1. The reader not desiring to read this anecdotal material may proceed to Section 3.6.3.

"As stated previously, a good fighter pilot (and an ACE is certainly that!) must first possess certain innate personality and psychological traits and characteristics. These are aggressiveness, alert thinker, quick and smart, hard-nosed and generally a 'leader' type of person. Given these attributes, he can generally be trained in the mechanical skills of piloting an aircraft. Those who do adapt to flying and who continue to demonstrate the personality traits outlined will generally succeed as a fighter pilot. The best ones, of course, have the best chances of going on to become ACEs!"

"I was fortunate to be one of the original members of the 56th Fighter Group. In all, 40 members of this Group achieved the status of "ACE" during World War II (air-to-air). To cite a single event which illustrates the qualities required of an ace would be most difficult. However, I will try. My advanced flying school instructor wound up in the Replacement Pilots Pool in England after our group had been in combat for about three months. By chance I learned this and I flew up to see him and to request that he be assigned to my squadron. My request was granted. From him I learned that to get to combat he had broken every flying regulation in the book while in Training Command. He wanted to be a fighter pilot. Well, one day on a deep penetration escort mission I was leading the squadron, and my old instructor was leading the third and fourth elements in our 16 ship formation. At rendezvous we were at 26,000' with a thin undercast - no bombers in sight - so I dropped through the undercast - the bombers were about a half mile ahead of us, and my eight jugs (P-47s) had come out about a hundred feet directly on top of 12 ME-109s, and immediately behind me about 1000 yds was a gang of FW-190s. I told my old instructor to bounce the ME-109s under me, and I turned to engage the FW-109s behind us. Well, Leroy Schreiber (my instructor) had a hell of a dog fight down to 12,000 feet. Needless to say, my elements had their hands full with not only a gang of 190s, but also eight ME-109s. Leroy had not seen the gaggle behind us. Finally, I had a call from Leroy - 'Little Pal, I'm at 12,000 feet - out of ammo with a 109 on my tail. I'll keep him busy if you will come and shoot him down.' I said, Leroy, I'm in a turning dog fight with a gang up here at 23,000 - I've shot two down and must now try to disengage or I'll run out of cobbs. Leroy back, 'Oh, O.K., Little Pal, didn't know you were busy - I'll duck in the clouds and lose this Jerry - see you back at base.' Leroy had 14 air victories before he was KIA on a strafing mission - direct hit by an 88mm. Leroy Schreiber had all the qualities of a great fighter pilot: aggressive; great courage; always calm; extreme self-confidence; and great desire. He used to say, 'Boy, if we were fighting for the Germans over our own territory, they would have to deliver our iron crosses in a bushel basket."

"Most of the fellows I knew who shot down many planes were 'hunters.' They worked at getting ready to fight, looked hard for the enemy, and when they found him, they went after him. In a sense they were rather deliberate about it, somewhat dedicated to their cause, and seemed to have a purpose in mind."

"The ability to simultaneously discover, evaluate, make a decision, act or react NOW!

"Simply to seek out, plan your attack, and execute your run against enemy aircraft or targets. As a flight leader, your wing men and squadron must be considered and informed of your intentions of attack or defense should the case arise. I usually said a quick prayer for God to help me use all my ability and training to execute my attack against the enemy. I cannot recall any event which would illustrate the qualities of an ace.

"This may be used if accepted - from personal experiences, I can only relate that as a small boy, I read two magazines that came out monthly. These were 'The Lone Eagle' and 'G-8 and His Battle Aces.' The authors of these magazines made a lasting impression on my life. I was determined to be an 'Ace' or at least a fighter pilot. I succeeded in both. Also, I know that a fighter 'Ace' is a special breed of man. This takes nothing away from the ordinary pilot or other men. However, in our breed there is a decided, inbred instinct to succeed, taking all risks, asking no reprieve; we know we can do anything, accomplish any mission and do it better."

"Know your job beyond question. Know that you can handle any 'reasonable' situation. Once a fight starts, get in and go 'full blower.' Last, but not least, be able to recognize when you have reached the point at which you should 'get the h--- out of here' and live to fight another day."

"Fast reaction (stay alive) flying wing in P-51A - no radio. First indication was FW-190 and tracers passing cockpit. Split-S'ed at impossibly low altitude and escaped! Visual and mental acuity - usually first to spot enemy. Make equipment operate at maximum; it

will do things they don't tell you about if the situation demands."

"For years people have asked what makes an Ace. Some special mental and physical attributes. Next February I will be 57 years old, and I can say I've seen many events illustrating the qualities required of an Ace. I've seen these qualities in many who never flew an airplane - executives in industry - men and women in sports in small towns and big cities. These qualities are aggressiveness, ambition and desire to achieve, determination to succeed and the impulse to move in spite of the odds. These qualities exist in all size, shapes, sexes and colors of people. And in people of different characteristics. Some are somewhat on the wild side - others very quiet and thoughtful - some are 100% dedicated to their occupation or the job on hand. All are successful to a degree but generally the wild ones run into a brick wall - the good mind with a great deal of thought generally quarterbacks the above qualities to success.

"The ability (head), guts (heart) and the mechanical ability (hands) to continue a mission that has all the earmarks of disaster from the very start. Take off on an alert - warning. Received at least 20 minutes after we were really effective. Climb to altitude on a vector that was wrong. Have peers drop out of formation for various reasons until only two are left in what had been an eight aircraft scramble. Each of remaining two aircraft get three each and have five burning in sky at same time. This takes a dedication of purpose to be a Fighter Pilot even if sick, if odds bad, and all other 'ifs.' This must be found - cannot be drilled in - recruit!"

"Maneuver always to take advantage of enemy - was flight leader of eight P-40s which hit a Jap Bomber force (Bettys) of 18 aircraft with head on pass - 12 Zeros were escort - one pass was made destroying two bombers and causing the formation to abort their mission and return to base. First time Japs had ever failed to get to target.

"With my wingman I attacked 12 German fighters that were attacking a crippled bomber. The odds were never considered because that is what I was there for. That was my function.

"I am reminded of my friend, Captain Swede Vejtasa, USN (Ret.) who was dispatched late as combat air patrol to protect the carriers Enterprise and Hornet from a dive bombing attack during World War II. The attack had started when Swede bored in. Diving with the enemy through fleet anti-aircraft fire, he picked off seven of the attackers. His gunnery was so precise he was able to shift sights from one target to another before damage was apparent. Just a burst 'on the money' than a new victim."

"I made Ace because I was willing to stick my neck out. I always maintained that only one aircraft can shoot at you in a dog fight at a time - so what if you are outnumbered? I think I was astute enough watching MIGs in action to notice that they never made rolling pullouts or turns at high speed. This resulted in my being able to figure out which way they would pull up from a dive and got me a couple of kills."

"Ability to evaluate the capabilities of your aircraft versus those of the enemy. In the P-38 and P-39 against the early and middle Zero, I had little or no trouble in making these evaluations with what I observed and in what my peers discussed. In the F-86 I had little or no trouble in achieving success against other F-86s. In Korea I achieved some damage against the MIG-15 but had no victories. After one encounter in which I was not successful in getting a kill, I finally only realized my error after a discussion after the fact with another ACE (Royal Baker). I just didn't realize I had to approach exposing my tail in chasing a MIG in a turn to get enough lead for a killing shot."

"He must love to fly. He must enjoy personal combat, as well as being conscientious and patriotic. He must be, at least occasionally, a risk-taker. He must know his equipment and that of the enemy. An example: A friend of mine, a squadron commander, saw enemy aircraft starting an attack, called out an alert, said to drop tanks if attacked, and for blue flight to take the first attackers. We lost one pilot/plane - they lost 8 - 10. Another friend, also my squadron commander (a different commander), saw enemy aircraft about to attack. He gave no attack instruction. I asked permission to break off attack. Permission granted. We got five aircraft - the rest of the squadron didn't fire a shot. Aggressiveness, common sense, and reasonable knowledge of equipment and aerial gunnery are essential! Seniority, without these abilities, should have no influence on advancement.

"From the time I was five years old, I used to watch airplanes till they faded out of view. By extending my outer limits of vision, I was able to spot more planes and always saw them before anybody else. To condense this sentence to one word - concentration. I attended eight grade schools in nine years and came to recognize and fight the bully in each school the first day. (I took my licks.) Condensation - awareness. I was not a "Golden Boy" athlete but earned my respect by working harder than anybody. My parents brought me up with faith in God, loyalty to Country (but not blind loyalty), and a strong desire to give more than I took. Condensation - self discipline. Other than these, you have to be scared enough to run faster than the other guy."

"(1) The guts to engage the enemy. (2) The ability to convert any situation to your advantage. (3) The cool quality to manage your energy and conserve your ordnance until inside the 'kill envelope.' (4) The ability to disengage gracefully and fight again another day."

"Aggression; Loners; Drive. Every time I saw an enemy aircraft I charged in - after all it's a fighting machine - no concern whatsoever for personal safety."

"Keen, calculating, positioning, using every advantage possible. Fire with enough speed to regain position and capitalize on any mistake the enemy might make while under fire."

"On the return portion of the first Shuttle mission into Russia (Axis Sally had passed us the word that her crowd would give the 325th their full attention on our way back to Italy); they did indeed - one of my flight leaders had to contend with two MEs. He kept yelling for help until I finally told him to stop his pissing and moaning and after he finished with his problem to come to my assistance - that I had five "cornered" all by myself. There were daisy chains all over the sky! The exchange settled the entire group down, and we successfully fought our way the entire distance to home base. Be calm, be professional and never lose your sense of humor. If you must go, do so with as much dignity and grace as possible."

"It would take too long to describe in proper detail. The essence, in my belief, is to have yourself so thoroughly trained and ready you perform without knowing exactly what you did. You literally fly formation on the guy until you get him. Had an ME-109 almost shoot me down - he's been on my tail for hours. Finally outturned him - got on his tail - don't know how I did it - shot him down."

"There must be a strong desire to attack. There is no room for hesitation."

"In my first engagement, having been vectored to intercept a shadowing Japanese aircraft, three of my four guns (50 cal) jammed and were unclearable. With one remaining gun, and intermittent jamming of it, I decided that I could not return to my ship (Enterprise, CVA 6) without scoring a kill. I further decided (with adrenalin running) I would have to chop the enemy aircraft's tail assembly off with my propeller to accomplish what was patently required. I proceeded to maneuver to close quarters on the enemy's tail to do this all the while firing and clearing the one remaining gun. Fortunately for me, at the very last moment I obtained hits (the rear gunner was already out of action from my previous runs) that sent the aircraft down - the pilot abandoned his aircraft, but his chute did not open - this kind of dedication to achieving victory (adrenalin or not) is required if one is to become an ace (opportunities permitting)."

"I guess aggressiveness has to be first, since our guns only fired forward. Good eyes or rather alert eyes has to be another. The ability to think and concentrate when, in any second, you could be shot down has to be present as a basic characteristic of a fighter pilot. He has to know he can fly the aircraft better than his adversary or even his mates - this gives him the confidence he needs to perform effectively."

"The good fighter pilot must be alert, eager, aggressive, yet calm during combat. His philosophy is, 'There are no goodbyes, and there are no regrets.'"

"Most aces are there because of circumstances, geographical or time/phase. These are the ones who have not lost wingmen. I personally lost none. High kill aces generally are more extrovert and aggressive, but also have lost wingmen. Is the trade-off worth it? People (USAF) rarely talk truthfully about losses."

"In the heat of battle where you're on an enemy's tail and still be observant of other aircraft in the sky. Once when I was on the tail of a German aircraft and circling with my wingman, I noticed another German slipping up on my wingman's tail. I told my wingman to keep a close lookout to the rear. I finally hit the aircraft ahead of me, and it started to spin to the earth. I then looked at my wingman's tail and saw he was receiving enemy flak. I was able to pull in tighter, and soon the enemy broke downward. My wingman then saw the second aircraft I was hitting and said, 'Where did you find this one?' I stated he was right on your ass."

"Dedicated to country or service. Aggressive, at least mentally so. Determined - one who finds reasons to do something rather than reasons not to do it. Ability - must have confidence in his own ability. A burning desire to be first, to be successful, to have some sort of recognition - even to a fault."

"On December 23, 1941, I engaged in my first combat mission. I was with the American Volunteer Group, in Rangoon, Burma. We flew P-40B's. Fourteen of us from the Third Sqdn., which had been sent to help defend Rangoon shortly after December 7th, went up in two flights to intercept a force of 52 Jap bombers (twin engine) and about 30 fighters (Nates and Zeros). I had had no aerial gunnery of any kind prior to this combat, and when the flight I was in attacked one of the enemy bomber formations from the classic high-side pass, I discovered that the deflection shot was a real bitch. Consequently, after missing badly on a couple of passes and breaking away at too great a range, I determined to fix things by boring in from dead astern on the next pass. I was fully aware of the fact that this made me a much easier target for all the bomber guns, but at the same time knew I should get results. I did, by boring in to within less

than a hundred yards on the last bomber, blasting away with my four .30 cal. wing guns and two .50's firing through the prop. The bomber blew up in my face just as I started to pull up; a cylinder head from one of his engines went through one of my wings. My elation knew no bounds; however, knowing I'd got one of them at least, no matter what happened later, I repeated the process, and a few minutes later another bomber was going down blazing. Meanwhile, I was shot up - a later count showed 93 holes in my plane, but nothing real serious. I guess the point is that I was willing to take a much greater risk in exchange for knowing I'd get the desired results. Others, of course, did the same, while others refused to stick their necks out to that extent. I need not add that the latter group never became Aces, nor did they gain much respect from the others."

"Guts and cool head! Flying proficiency is minor item. Numerous pilots in our squadron (New Guinea - Fifth Air Force - P39s in '42, P-38s in '43-'44) performed poorly in combat due to non-aggressiveness. They tended toward snafu-itis - this trait can only be described as 'lack of guts.' Many examples can be given by those of us who did perform our combat job - flight proficiency does not make an ace - 'guts' is the primary requisite! No guts - no victories! After 'guts' comes 'cool head,' then proficiency."

"(1) Good physical coordination with quick reflexes; (2) Keen eyesight with good peripheral vision; (3) Aggressiveness; (4) Guts."

"Aggressiveness stems from the top - if the leaders are not aggressive then the unit most likely will not perform well. A P-38 outfit that I belonged to could only think of a Lufberry circle when engagement occurred. The leaders didn't have confidence in the aircraft and constantly used it in a manner to its disadvantage, i.e., very high altitude instead of medium to low altitude. To offset this, I was constantly talking of more aggressiveness to my flight and squadron members and to use the aircraft to its best advantage."

"Protect your friends first. Your victory is secondary. Captain Pete picked up a ME109 on his tail over Gabu, Africa. I had a good set-up on a FW190 off my left wing. The 109 on Pete was a long shot and not as well set up as the 190. The 109 on Pete was about an 80° deflection. I took the 109 off Pete and almost got it by the 190 who maneuvered behind me. Pete almost kissed me upon return. Look around, look around, look around! Over Salerno, Italy, the controller gave me the position and altitude of a squadron of ME109s about to strafe the landing party. I climbed to a higher altitude and headed to the sun side of this reported position. We were all looking down to see them first. They, however, had split, and we were surprised by a coordinated attack from above just as we were tipping over for an attack on the lower gaggle. We did not look around enough. Result - a couple of P-38s shot up but no losses - enemy lost five."

"We were flying P-51s on a ground attack mission over Germany. My squadron leader was shot up by ground fire. As he went down, on fire, I told him to land on a hard surface so I could land and pick him up. He ordered me to take the squadron home. I refused. He crash landed in a muddy field, and I landed in a nearby wheat field that had been partly mowed. As I taxied in circles waiting for him to get to my airplane, I came under fire from German soldiers. I returned fire with my service pistol, setting a truck on fire. When he arrived, I threw out my parachute and dinghy to make room for both of us in the single cockpit. I sat on his lap and flew the airplane off - only slightly damaging a haystack in the process. On the way home, I overheard a dog fight on the radio - between P-51s and FW190s. I tried to get DF vectors to the dog fight so I could join in - but was refused - so I flew on back to base with my passenger and landed safely. I was then brought up on disciplinary charges for disobeying direct orders under enemy fire. I ended up with a reprimand and a big decoration. Looking back now, I can't recall what went through my mind during this episode - but I'm reasonably certain that it never occurred to me at the time that I was taking any ill-advised action or, for that matter, incurring unnecessary risk. Nor am I qualified to describe whatever personal qualities that might have been involved. In retrospect, however, and with all humility, I suppose that if I were a battle commander today, I would hope that my young fighter pilots would exhibit a similar attitude under fire. If so, I would discipline the hell out of them, decorate them, and fight to keep them."

"Desire to chase and overcome the enemy sometimes causes you to ignore either operating limits of the equipment or what might be considered prudent restraint. An example in my case - night fighters - pursuit and kill of a Japanese float plane at 100' altitude between cloud layers - no moon - and 70 knots airspeed which required wheels and flaps down to stay behind him. Aircraft was constantly flying evasive action and releasing 'window.' I probably should have left him as he was harmless."

"I led a flight of eight on an armed rescue mission which was a total failure because we found no 'action' and returned with guns still taped. On return we found our base closed by weather and set down at another fighter base north of our own. After dinner, we retired to the club bar where we had a few with pilots of the other group. 'How did your day go?' I was asked. 'Lousy - we didn't see a thing!' 'Same here,' their leader told us - 'we saw 16 109s once - but there were only 12 of us so we avoided them!'

We couldn't believe what we heard, and our pilots actually went off to a corner by ourselves so we wouldn't be contaminated by their attitude. We felt our success came from association with people like 'eagle' who called to us in the heat of one aerial battle 'Hey, you guys - come on back behind the last box of bombers - I'm all alone and I've got a dozen of the B _ _ _ _ _ _ s cornered!' That is the total of all qualities required of an ace."

"First - desire to fight; second, ability to shoot."

"Aggressiveness - the willingness and confidence to get in there and fight."

"My first victory resulted from a head-on pass and mid-air collision wing to wing (enemy broke at last second). Although I don't recommend the technique, it illustrates a prime requirement - giving first priority to destroying the enemy rather than to surviving the fight - I don't advocate Kamikaze tactics, however."

"Be sure of your shot. Close in and conserve your ammo and your fuel. Remember, you want to be able to get home - back to the field or aircraft carrier. If you run out of gas, you've tactically been shot down; and there goes an aircraft that could have been used tomorrow."

"Desire, motivation, aggressiveness are key. Seeing enemy before he sees you helps in positioning and final destruction of aircraft. Knowing the capabilities and limitations of your aircraft related to enemy can never be overlooked."

"(1) Attack with advantage; (2) defend with maximum skill. In all encounters, even with very good fighter pilots, I found that it did not pay to fight on an even basis. In all the kills I had, the enemy pilots were either surprised or were not as skillful as I in air combat maneuvers. I have no specific instances."

"The desire to go another step forward. When escorting bombers, my flight stayed with stragglers longer than other fighters. As a result, we saw more action. When strafing railroads, we hunted just a little longer. It was not bravery - it was a desire to hit the Germans one more blow, and an ambition to be just a little better than others in the squadron."

"WINGMEN: One of the essential qualities that a successful air-to-air combat pilot must have that is often touched upon but seldom given its proper significance is a CONFIDENCE AND TRUST in his wingman. There is no way that a fighter pilot can go into a serious fight and do other than snap shooting if he doesn't have complete and full confidence that his wingman is capable and on duty. To get a victory, steady tracking and a good long burst or two are required after you have obtained position. You can only do this by concentrating fully on your target. The relationship of a pilot and his wingman, that provides the confidence for the leader to be successful, defies explanation. It is so tough that each can be called on to die for it and some do; and at other times, it is fragile. It's more like a leader-faithful follower where the synergistic operation of two qualified pilots far exceeds the expectations of the two taken separately. I think you see this kind of thing in football where you have a successful twosome, one a good ball carrier, the other a good blocker. Together they become exceedingly capable. The general success of this in football is known as teamwork, but when you get the right relationship, you develop a superstar. The characteristics that allow such a dependency bond to develop must lie within a successful fighter pilot. Chances are that he will need it several times during his career if he engages a serious enemy."

"The only way I became an ace was my ability to hit what I was shooting at. This sounds obvious but I mean - I grew up with a rifle - 6 years old, and shot gun - 9 years old. I fed my family at age 9 until now with a gun. Until I started losing my good eyes (nearsightedness), I could kill a quail flying with a rifle. An airplane was just another gun to me, and I had a cocky confidence. I thought I could outshoot any man who walked, and I still think I could. I have seen pretty good flyers who couldn't hit a barge strafing. This may sound incredible, but they could not. Something that I knew and did and I'm sure a lot of other guys did was get in close. Six 50s and a 20mm are like a cutting torch up close - I mean 20 yards or so - and when you touch 'em off at that distance things happen. I only had air-to-air combat on seven or eight occasions, so the only way I got what I did was I could hit 'em and the angle didn't matter. I'm not bragging, I'm trying to help."

"Never to concentrate on your target very long so as to block out your side or even peripheral vision; rubberneck yourself - illustration - in October '44 I led a fighter sweep in the Visayans, and we were burning Bettys and other twin engine planes parked on Cebu Field. One of us (not me) saw a dust ball moving across the river and downstream about two miles. He did a wingover and took a closer look. It was a Jap fighter strip (Mactan), and Zekes and Hamps were taking off! He 'Hey-Rubed' to the rest of us 'mohawks' and we shot down 14 of them confirmed. My first one of these still had his wheels down. All of us got back to the Lexington in time for supper. Had they got their altitude, it might have been

different. So even dust can say something to you if you or one of yours just keeps on looking around!"

"(1) Your knowledge of your own weapons system including the aircraft. Training and practice in operating the airframe and engine to its max. (2) I saved my life on several 'enemy at six' situations by being physically able to overstress and still fly and shoot. In one such situation, I did an inadvertent snap-roll and spin (in Korea) in formation with an enemy MIG. We both recovered shooting then back into a spin. On the third recovery, I shot him down. Through the spin I tried to keep my eye on him. I don't remember worrying about the spin problem. I do remember his being in position to take a shot at me on our second recovery. (3) I believe you have to charge into a fight although it may scare the hell out of you which is good, because it gives you super strength. No problem or thrill with slipping up the tail of an unexpected target and blasting him out of the air."

"I began to get dead serious when asked a question like this because the 354th F.G. Ninth A.F. racked up an air-to-air kill score that was not equaled! The quality that made me an ace was the ability to follow example. What made me an ace was the ability I did not know I had, to never let those examples down. The leadership the 354th had in its Eaglestans, Howards, Martins, Beechavens, and Turners was what turned me on. If you have the leadership the rest is never any problem!"

"(1) Quick reaction; (2) wide field of vision; (3) be able to hear, understand what you hear and think while you are maneuvering and/or shooting."

"My personal observations lead me to believe that the person with the most desire combined with average skill and, of course, courage would be the top pilot. An incident occurred on one flight led by an officer who had not engaged in combat and had been in the theater over a year. Bandits were called in by me - our level nine o'clock. Our great leader promptly turned right to three o'clock. This man should not have been a fighter pilot. Incidentally, as I was ass-end Charlie, I promptly returned the favor and left, engaging in combat on my own."

"In trying to recall a single event, I thought of my own and others' experiences, and there seemed to me an important common ingredient that perhaps separates the exceptional from the average. Air discipline."

"(1) Ability to fly; (2) competitive instinct and a desire to win. My best pilot was John Hampshire. Fourteen kills in about five fights. When he reported for duty, I tested his skill against my own. His formation was perfect. At the top of a loop, he took his hands off the stick and made faces at me. In A.C.M. I was never able to get a decisive advantage. When we landed, he was all excitement. The action was over the field, and the crew chiefs were in on the debrief. That is where I learned that half the fuel had been drained from his tanks to get a weight advantage. His explanation was, 'I want you to know I'm going to do everything I can to win,' and that he did until a bullet in the stomach brought him down. He ditched in a river, gear up, and was brought ashore where he lived a few hours."

"On two missions I dived under Zero cover to shoot down a bomber. I was not concerned about anything except getting the bombers. Each time the direct and determined attack surprised and confused the enemy. See your job and do it."

"This is not a single event, but from my combat experience I found out quickly that I was not good trying to shoot, even from small deflection. Therefore, I always had to fight hard to get on the tail for a close - no deflection shot. With the less sophisticated equipment of WWII and Korea, an expert in gunnery training was not necessarily the making of an ace. It was more determination, aggressiveness, and knowing how to fly an airplane to its maximum performance."

"Aggressiveness is a basic requirement, coupled with knowledge of your equipment, and the desire to accomplish your objective which is to kill the bogie. Being able to perform flawless acrobatics/maneuvers, etc., may look pretty, but the drive to press the attack to ensure the kill is the key - the only payoff is the results, i.e., the kill."

"Anger at being jumped, unexpectedly, yet through use of knowledge of aircraft limits reverse conditions to become aggressor. (Korea on air-to-ground mission - at low altitude. Jumped by four Chinese aircraft - dumped all external ord. and destroyed all four enemy.)

"I got into my first one on one 'dogfight' (with a fellow student pilot) more or less by accident while in 'Basic' at Merced, California in 1942. I got whipped but good, and it was humiliating. I made up my mind then and there it would never happen again - that I'd tear the wings off my aircraft before I'd ever let anyone else get the best of me in any form of aerial competition. I refused to admit there was a better 'fighter pilot' than I anywhere in the world, and I refused to be beaten. I haven't lost a real or 'mock' dogfight since then."

"March 1945 - USS Hornet off Kyushu - under attack by Bettys-Nells all night - at general quarters - very little sleep - predawn launch to lead 16 fighters on sweep over Kanoye airfields; 300' ceiling - light rain - started launch while Hornet under attack - six fighters launched - other ships were firing at those six VF - we doused running lights - I broadcast

course, speed, and rate of climb. I had six fighters joined before daylight, and we approached Kyushu at about 20,000', three sections essentially abreast, ready to fight. About 15 Zekes were above and waiting - I spotted them early and continued climbing to them. The Zekes' attack was regular, but not well coordinated. We maintained a figure 8 track, covering tails, and descending slightly to keep good speed, and importantly, slow the closing rate to give our defense a little more time to cross over and take a shot. Wingmen hung on and also got in some bursts. I got two Zeros here and the other guys got three or four. We penetrated, continued toward Kanoy. Resumed climbing - spotted another group (loose) orbiting north and above - again, we carried it to them. This group was not as aggressive - they made indecisive runs and instead of breaking down, or hard away, passed through, straight ahead, obviously inexperienced. I got two more - my wingman got two, section leader one, and four more got one. My third section leader got two - and we never broke out of our figure 8. Following this action, we patrolled down the bay, saw other U.S. and enemies in a couple of dogfights, but stayed at our 15-20 thousand feet. Shortly, we saw a Corsair chasing a Zeke in a vertical circle. Another Zeke was trying to close on the Corsair - two on one didn't seem fair. We nosed over, closed, from the after quarter for near no-deflection runs. I got the one on the Corsair's tail, and the three section took the other one. The Marine Corsair gained on me, and was he happy. Radio and navigation aids had been shot out. We made one more turn around the beach. They made runs at us, and when I ran out of 50 cal. (and a couple of my other guys), we moved over and ran away from them. They maintained altitude. Of those six pilots, I was the leader - and had most opportunities to shoot - and I was the only one to finish war as an ace. But, for my money, not many aces would have shown the discipline, alertness, HEART, perception to my moves, and the spirit to take 'em on. In my book, those fellows flying with me were the real aces. It is much easier to lead, when backed up by such fine naval aviators as - my wingman, Little Braze - Wild Bill, my section leader - Ehiefie (a real Indian and highly capable), the tail end Charles - Willis (none) deceased, my regular second division leader, and his section leader (Cullie). These six were launched in most adverse conditions, then the deck was closed until dogfight about 40' later. Just think, we had the whole thing to ourselves for about 40 minutes and had a barrel of fun."

"Need to have a sincere desire to engage in combat."

"(1) Good eyesight - being able to pick up the enemy aircraft before anyone else. (2) Being cool and not getting excited. (3) Good aircraft position and this is the result of #1. (4) Being aggressive, knowing your ability of of your aircraft and not being afraid. (5) I am a small man (5'6", 145 lb); but when I put on a fighter, I become the biggest man in the squadron or in the air."

"I guess a good fighter pilot has to have good eyes; good reflexes; little or no fear of consequences; not necessarily a good thinker, but one who is dedicated and cock-sure he is the best. Wrap this all up in a good physical being, and here I don't mean a super athlete (some have scored well with less than all their extremities) but one who thinks physical, because this is a physical way of life - and I guess I ought to throw in a little luck - that hasn't hurt anyone."

"Ability to react quickly - to evaluate the situation quickly and accurately. To hesitate means possible defeat."

"Yes, during Korean War I was leading a flight of four F-86s. I decided to head for an airfield about 75 miles north of the Yalu River (against the rules?). We were at about 45 thousand feet. Upon arriving I noticed numerous MIG 15s taking off. We were aware that the enemy sometimes put a protective cap over their fields. We started down in a high speed dive. As we passed through about 20 thousand, my #3 man and myself both observed about 20 MIG 15s circling the airfield. Since we had lots of speed, we continued on down after the MIG that had just taken off. Before the protective MIG cover could get to us, we had shot down five MIG 15s in about one or two minutes. We broke south at once and by using some cloud cover and some rather violent maneuvering managed to evade the MIGs we had left above us. Were we foolhardy? I don't think so. I think it was a good calculated risk under the circumstances. It paid off. Five MIG 15s destroyed. No losses."

"It was my seventh combat mission. I was leading a flight of four. We spotted a group of 45 German dive bombers escorted by 10 ME109s - altitude about 6,000'. They were attacking our ground forces. We went in to attack the bombers from the rear knowing they did not have rear guns. After shooting down two, I started on the third thinking it was easy. ME got me. I parachuted, was rescued and returned to my own field. One of the group's other pilots questioned me about my attack methods, and I told him if he saw any of that type aircraft to slow down and get them from the rear at same level. The next day he was on a similar mission and got four of them. He told me he did as suggested and also worked his way up under them when escort appeared, returned home out of ammo. Know the enemy, your aircraft and be alert; stay calm. He did and became an ace with 10 kills. He beat me, damn it."

"First there are a hell of a lot of good WWII fighter pilots who are not aces. Also, many of them are not aces because they always did the job assigned and did it well. For example, if

you were assigned to close bomber cover and you did your job, you very seldom shot down a plane - your job was to snap shoot or fly so as to break up the enemy close-in attack. You could not concentrate long enough to shoot down the plane or the next enemy fighter would get by you. How? There are some guys around today that didn't play these roles; and they ran up a score, but people know who they are, and they have to live with their actions. Finally, the enemy is always at least as scared as you - only so many planes can concentrate on a target - so a gutty, aggressive team action always pays off."

"An ace has, above all other, an instinct to kill. Some pilots do not possess this trait. Some men simply cannot kill. Once this is recognized by the individual, then opportunity is the remaining ingredient for air-to-air kills."

"To be scared as hell until the enemy is sighted. Then to quickly evaluate the situation and take up the offensive. To lead in an inspiring manner giving encouragement and example to all. Never give up no matter what the odds. Concentration."

"In China (July 1942) I was 23rd Gp. Cmdr---(CATF). . .Lt. Dallas Clinger was my wingman (after this action). We had just landed with the 'group' (some dozen P-40Es) for refueling after combat (Ling Ling) - as we made all the haste possible - refueling from old 4 gallon British jerry cans---we observed outnumbering Jap. Zeros---coming towards us, just as though they knew we'd be wide open - on the ground. But as they approached we noted two P-40s - they were chasing. Of course all the slower P-49s could do was get their noses down and run - to make the famous maneuver 'getting the hell out of there.' Because it was not only an unwritten 'law' it was from an order - down from the Old Man, 'Never turn with a lighter Zero.' But to our consternation, one of the P-40s made a 180 degree turn and engaged the pursuing enemy - head on. Each time the Zeros turned themselves and did their best to shoot him down- in a sort of replay of long outmoded WWI tactics - dogfighting. To make a long story short, this lone P-40 turned back into the enemy gaggle three times, damaging two and destroying one Zero - later confirmed. By that time we had a few of our fighters refueled and back in the sky - to maybe help. The enemy never got to strafe us helpless as we'd have been had they absolutely ignored the 'foolish' lone plane. Later that afternoon when I had stopped 'biting my nails' - I found the pilot of the attacking P-40 - this Wyoming cowboy - Lt. Dallas Clinger. 'Lt.,' I said, trying to keep from courtmartialing him there on the spot, 'you know damn well you violated Gen. Channault's written orders about never, never turning with a Zero - oh, you were lucky and maybe you kept us on the ground from being strafed, but nevertheless - the Old Man will be asking me - so I am asking you - why in the hell did you do it?' Well, all this super confident green-horn said was, 'I just got so mad, sir - when I saw you all down there refueling, and so I attacked - I couldn't help it, Colonel. Maybe I was wrong, but I attacked.'

"My point here is simply this - here was a kid from Afton, Wyoming, a fine pilot but inexperienced - in a strange land - outnumbered so much it was staggering (estimated something like hundreds to our 49) as far as aircraft went in China - and everyone knew it - YET HE NEVER HAD A DEFENSIVE THOUGHT - HE TURNED AND ATTACKED.

"No wonder I chose him for my wingman - I suppose I explained to General Chennault something like, 'Sir, I will watch him.' In three months 2nd Lt. Clinger was an ace - and maybe I am still around because he became my wingman.

"#2 - Johnny Alison - a Major then - a retired Major General now - who became Vice President of Northrop Aircraft. On the night of July 31, 1942, John R. Alison from Micanopee, Florida, shot down three Jap bombers and damaged two others over Heng Yang, China; the first night action of the war over China; the first time the beleagered Chinese had ever seen the enemy destroyed over their defenseless cities. Only thing was in making his attack - right up the tails of the formation of bombers - Johnny had to simply ignore the waist guns and the tail guns and bore on in for the kills. So by the time he had gotten to three and four he was hit himself - on fire and about to go down in flames - yet, he continued to deliver fire until the last Jap was either going down or had broken away - its attack abandoned. Why was Johnny attacking alone - I had better explain that to the uninitiated. We had agreed by assigning altitudes to our fighters - four of them as I recall. So, as the enemy attacked that full moon night - up the Siang Kiang River from Hankow to Heng Yang (a bombers moon the Chinese always called such a night of terror) our other three fighters were at staggered altitudes and so as not to hamper whoever became the lucky one at the enemy's selected altitude - we had to just watch and wait. But anyway, as the formation was broken up - most of it on fire - all I could do was watch Johnny Alison in his lone P-40 - in flames himself - it seemed that fighter of his was trailing a 30 foot plume of solid flame. Radio silence may have been the order of the day - but suddenly the air was filled with instructions to Johnny, 'Get out - Johnny - bail out - you're on fire.' Over and over we called to him - only to see his plane crash into the river.

"Again, to make a long story short - and besides I have already written this incident up (at length in a book that is a good 34 years old). When the cheering Chinese had fished Johnny Alison from the river and brought him back to the field across from the city - my first question as I grabbed his hand and cheered him also was, 'What was the matter, Johnny - we were

yelling at you to jump - you were on fire from prop-spinner to tail. Didn't you hear us?' I never will forget if it was 134 years instead of a mere 34, 'Oh, I heard you all, Colonel - but I had to stay with the plane - we needed the parts. I could see the whole thing reflected in the river - I just had to ride it in.'

"Get that - 'We needed the parts!' - which was typical out there in China at the end of the supply lines - besides we knew we were mighty far down on the totem pole of supply anyway. But this fighter pilot - with his plane taking down to a fiery grave - was not thinking of defense or abandoning anything - much less just saving his life - he was thinking about the future and tomorrow and getting that plane either flying again or at least to save some of its vital parts for what we know now as 'cannibalization.' You see we had a factory at Loiwing or Lashio - in the China Theatre - where the Chinese would take about eight or nine or even ten wrecked planes and build one that was combat-worthy from all the parts. It sort of reminds me again about the Israeli Air Force I mentioned earlier - maybe we were the same way then - we were so short of everything - manpower, plane power, ammunition, gasoline - all we thought about was soulless hardware - but these were our national monuments, heavy and cumbersome and slow as those old cast-off P-40s were. (Major Alison received DSC for this valor.)

"In closing this - I could sit here and write another book about what I think about fighter pilots and how varied and different they are - but I will mention just one more - who died - running for his P-40 at Ling Ling or Lieuchow or someplace like that - instead of running for cover and a slit-trench for safety. His name was Johnny Hamshire and he shot down 14 enemy aircraft in about that number of days - surely half that many weeks - he might well have been one of the world's leading aces - had he not been killed that day. He was the most offensive minded man I ever met. But while his flight was refueling in came the Japanese fighters to hit the grounded planes, and of course he had only one thought - get up there - in his cockpit - start that P-40 and attack. But he died. Therefore, I close this epistle with the thought that to me the greatest qualities I ever observed to illustrate those real qualifications of an ace is just that, 'I had to attack, sir - I couldn't help it, Colonel!' Hadn't Johnny Alison really said about the same thing - when he said, 'We needed the parts, sir - we needed the parts.' Oh, Major Alison went on and on to become a double ace, and is still going strong - and he surely knew Johnny Hamshire, too - because he was his squadron CO. Of course, Johnny was one of the best pilots there ever was in this world - I could write a book about him - so were those other two good pilots. But the only thing any of them really had in common was that feeling that fairly leaped out at you - 'Attack. Never, but never, have a defensive thought.'"

"(1) With training, confidence developed. (2) Throughout my 30 years in military aviation, most of the time I flew in fighter aviation, it was found that when I could maintain 20-30 hours of flying time, I felt as though I had a true proficiency with flying - the aircraft I was flying and the unknown situations that could be encountered. This time was acquired under a well-directed program with supervision. Even so, I personally knew my limitations and tried to work them out myself. (3) In contrast, when I served on staff assignments where some eight hours/month was required to bore holes in the sky - I lost proficiency. (4) An intensive refresher course is important to revamp a staff pilot back to fighter-combat proficiency. (5) In peacetime, fighter pilots can be assigned additional duties but in wartime - this individual should be highly specialized and not be subjected to additional loads other than training and combatting in this specialty. (6) A squadron and group commander must be an active, proficient leader. He must strive more than his subordinate to maintain flying proficiency. His command duties is not so much 'directing' as 'follow me.'"

"I recall a mission in China when about ten of us in P-40s were pursuing a flight of Zeros. Johnny Alison was already in the air before we took off and had made contact. He called us and gave us the position of the Zeros saying, 'you guys come on. I've got 30 Zeros cornered!' Johnny was the best fighter pilot to strap on a P-40 (never an ace maybe, but the best of all). The quality illustrated is aggressiveness, eager to fight - good at it!!"

"After shooting down one aircraft - going from 32,000' down to 7,000' - I climbed up to 27,000' again in hopes of engaging another aircraft - rather than going home. I was successful that day - perhaps a bit foolish, but it paid off. The next time I climbed back up after a similar (double) kill I ran into an F-51 and he shot me down (my mistake). Thus, my aggressiveness paid off once, but almost cost me my life the second time. I would rate aggressiveness #1 as an attitude, but it is not something necessarily manifested outwardly. If it can be identified through tests, then I would favor that kind of person."

"I remember very clearly one of our leading aces saying on the radio during a rather large hassle, 'I've got about six of 'em cornered back here!' That, to me, is a graphic demonstration of the spirit and guts that it takes to make an ace!"

"My very first 'real' engagement of the enemy and my first kill, began after a B-17 bomb run, when a buddy and I saw about a dozen 109s below and obviously heading home. We dove, getting

good speed and went after them. About a thousand yards from them, they split, half turning left and half to the right, when the question was put to me, 'which group do we choose?' He had his answer in seconds, 'Why share, you can have the group going right, I'll take the group going left - good luck.' As I recall, he got two confirmed, and I ended up with one kill, one probable and a damage."

"I wanted to meet an enemy fighter aircraft in combat in the worst way, and didn't care what the odds were, i.e., two against two, four, or the whole enemy Air Force. Just finding a MIG in North Vietnam was generally difficult if you were flying MIG Cap missions. Therefore, I obtained as much information possible during the entire tour on their probable airborne locations, geographical position, altitude, etc. This paid off twice. I attacked a flight of 16 MIGs with no F-4 losses. Having the eyes to acquire these flights was extremely important also. So I guess it boils down to an intense desire for air-to-air combat, good eyes and self confidence (assuming flying skill is there)."

"Contrary to popular ideas, shooting ability and not flying ability has always been the fighter pilot's most important asset, and the asset most likely to make him an ace. Air-to-air shooting ability is an esoteric skill, and few indeed are ever to master it thoroughly. Those blessed with the native ability to shoot at a moving target from a moving platform, the movement of both being in three dimensions, will almost certainly become aces, even if they are not exceptional pilots. In comparing the smooth-as-silk pilot and the ham-fisted rough pilot, the smooth pilot's reactions in the air are predictable to an enemy pilot of similar skills. Where the smooth pilot takes evasive action, the enemy can sometimes predict it in advance and bring his guns to bear with a well aimed burst. The ham-fisted, rough pilot, on the other hand, often reacts unpredictably when bounded. His salvation lay in his sheer brute force. He'll wrench his aircraft into turns an experienced pilot would never attempt. But smooth or rough, the fighter pilot who could shoot was likely to become an ace if given adequate opportunity."

"Confidence in oneself and in the aircraft; aggressiveness; thorough knowledge of the capabilities of your weapons and of the enemy's limitations."

"Determination; self-centered egotism; belief in oneself and his ability; self-discipline to study enemy aircraft."

"When I first joined the Eighth TAC Fighter Wing at U'Bon Royal Thai Air Force Base, Thailand, in September 1967, the Wing Commander was Colonel Robin Olds. He had with him a nucleus of older, highly experienced tactical fighter pilots who functioned as squadron commanders, operations officers and flight leaders, and, I believe, this was the most efficient and aggressive wing of fighter pilots throughout the Air Force at the time.

"However, as Colonel Olds and these other experienced fighter pilots finished their tours, they were replaced, for the most part, by pilots coming out of SAC, MAC and ATC - essentially non-fighter pilots who had gone through a six-to-nine month training course in the F-4 and were now considered combat qualified. These 'new heads' had to be lucky to survive 100 missions over North Vietnam, much less become top scorers. I think this policy of rotating pilots out of non-tactical aircraft and into a high performance tactical fighter like the F-4 or F-105, and then placing them in a combat environment with minimal training was ridiculous. It would have been better to assign new pilot training graduates, those who could handle it, to F-105s and front-seat F-4 positions rather than these retreads from SAC, MAC and ATC. Either that, or require that the experienced TAC fighter pilots, such as Colonel Olds and this nucleus I mentioned earlier, fly more than one combat tour."

"After making our first attack on a SAM site (April 1966) Hanoi - #2 man said, 'Lead, that was 'Shit Hot' - find us another one.' We did and he (Harley Wyman) put all his bombs right in the center - (bye-bye radar). Both sites were confirmed out (one mission). Heart and desire to do the mission. (First multi-SAM kill of the war - both sites confirmed - out)."

"I am personally acquainted with all three of the Air Force aces in Vietnam. The qualities which best typify these individuals are as follows: (1) Generally excellent in aircraft handling and tactics; but this not the most important. (2) Imaginative and planned to get kills by taking advantage of the opportunities presented. (3) Their ability to execute plans carefully made and considered. (4) Coordination in two-place aircraft among crew members. The ability to take advantage of opportunities with careful preplanned tactics was critical. A typical situation is as follows: Enemy fighters would typically use different bases to launch and recover. Because of the limited high speed engagement capability of the MIG 21, recovery could be predicted depending on the direction of the strike. One of the rover MIG CAP tactics would be to penetrate the SA-2 SAM rings at low altitude and attempt to engage the MIGs on recovery. Probably 50% of the squadron's kills resulted in such tactics, since the MIG pilots were ill-prepared to fight in this environment. It was extremely difficult to engage the MIGs at your convenience, since their excellent GCI precluded your ability to intercept prior to their attack. On a flight I was on, we caught a MIG 21 recovering at Fuc Yen on the downwind to GCA (it was their

procedure to get vectors straight in) - he was at low airspeed maneuvering. We came on the deck at Mach .95 to avoid the SAMS and got a snapshot kill with guns. This was not just luck, this was a carefully planned and executed calculated risk. We were fired upon by SAMS while in this engagement. Our ability to defend ourselves from SAMS was vitally dependent on precise tactics of the rest of the flight."

"So many of the engagements required the confidence and knowledge to react at a second's notice to a given situation (i.e., pulling off the target and seeing an enemy aircraft in front of you and being able to adjust from an AB to an A/A environment.)"

"Yes, aggressiveness (tempered with judgment) can even be displayed on air-to-ground missions (I was an air-to-ground pilot at U-Bon's Eighth TFW Wolfpack). The lower a person dive-bombs, the more accurate he is. And when a person continues to drop at a lower, more accurate altitude even when AAA is flying all around him, he will also be likely to 'fill his windscreen with enemy airplane and blow his stuff away.' A person who does not rationalize in air-to-ground work is not likely to do so in air-to-air work. Instead, he will press the attack at all costs. This is my philosophy and the one I flew by when I was flying in SEA/NVN."

"(1) The spirit of attack born in the heart of a brave man (Galland). (2) My first engagement occurred on 8 July 1972 when I was attacked by three MIG 21 aircraft. After the third flushed through, I started after him and fired; he went into the biggest, blackest cloud in NVN and I went in right after him. When I came out the other side, he was still in my pipper and I got him. I really wanted to kill MIGs. The next time I saw one I chased him for 20 miles across NVN and fired everything on board - no kill. In December 1972, when operation Linebacker started, I was scheduled to go on R&R to Hawaii with my wife. I cancelled the trip to get a chance to get another MIG. I really wanted to be an ace."

"First requirement is the opportunity. A fella needs a reasonable war with acceptable ROE. Second requirement is for the proposed ace, besides being good, to have personal organization which is developed through training of mind and physical capabilities. After these squares are filled - attitude, a good fighter, missiles, a gun and a little luck are all that's required for a person to become an ace. (Naturally as the plot thickens - fighting over heavily defended areas against great odds - a willingness to take chances and accept a few shots becomes important.)"

"An apparent coolness under fire/pressure, i.e., individual effectiveness seems to increase as the pressure mounts. This man will do well in any performance situation, may not do so well nor even be noticeable in the mundane low pressure environment. Coolness under pressure becomes apparent as the pressure/stakes mount. One can almost see the excitement, fear, etc., wash out to be replaced by the cool, methodical effective 'machine.'"

"There are so many events it would be impossible to describe all. Attributes required:
(1) Certain basic intelligence level.
(2) Dedication to air superiority.
(3) Attitude. (4) Aggressiveness.
(5) Leadership ability."

"(1) Desire to become an ace. (2) Preparation, practice. (3) Rigid discipline. (4) Teamwork. (5) Supreme optimism."

"Desire to engage, good tactician, desire to press fight once engaged. Self confident, well disciplined, responds well under high mental and physical stress."

"Competitive spirit. Guts. Knowledge of the air-to-air situation and an absolute urge to get into a position of advantage. Unyielding desire coupled with the capability and dexterity to perform in the air-to-air arena - few can do it!!"

"Outstanding ACM ability; aggressiveness; cool head; prior game plan well thought out. The four above qualities are required to become an ace plus a lion's share of chance or luck. This is illustrated in any well briefed, well flown and well debriefed ACM hop."

"Yes, a friend of mine - Randy Cunningham.
(1) Aggressive; (2) cool under stress;
(3) excellent stick coupled with common sense;
(4) under the surface cocky as hell but not apparent to those not associated with the air to-air breed; (5) consistent. All of these qualities are present during each of his kills."

"My kills were determined long before the engagement. As the engagement began, I distinctly remember that there was not a doubt in my mind in most cases as to what should be done. In fact, the only problems I had arose in those instances where I had not given adequate thought to some individual eventuality and was forced to make decisions which were safe and correct but were not aggressive enough (training dictates, and rightly so, personal responsibility for the aircraft you are in). A person must commit themself to what they are doing and direct an inner power and thought to what they are doing."

"You miss the point! An 'ACE' has no qualities - he has timing and luck on his side. An 'effective combat pilot' must have the following qualities: (1) a thorough knowledge of his aircraft and the hand/eye coordination to take his plane to controllable limits at will; (2) he must have the decisiveness to

know when to back down and the maturity to accept failure. He must learn all he can from his mistakes because he will not always find himself at 6 o'clock; (3) A combat pilot must assume a heavy heart in awesome responsibility but he must hunger for light-hearted competition in achieving the final victory; (4) The fighter pilot must have ultimate awareness of his own capabilities that he might better understand those with whom he flies; (5) He must not waiver from a decision made, but he must pray to God he's made the right decision."

"I was assigned to Randy Cunningham's room after he had been detached from VF-96 (I was aboard for only two weeks). He had left two items - a stack of well-thumbed books by WWI and WWII aces and a dog-eared NATROPS manual. He knew the airplane and was smart enough to learn from other's recounts of their experiences. Moral: Personal motivation and innate skills are one thing, but success requires a thoughtful, dedicated understanding of the concept of air-to-air fighting."

"Varied events occurred which involved both fighter pilots (F-4/F-8) and attack pilots (A-7/A-6). In all cases, I believe, the most important single factor is an individual's ability to continue to think and make rational decisions under the most adverse conditions. Any man can be overloaded; but the last man to lose his head might generate a situation that permits a kill or allows him to get out of a very bad situation alive. Flight ability, weapons knowledge, etc., is assumed."

"Unless a person is very lucky, success in combat is directly related to preparation. I am using preparation in its largest sense to include training, physical skills, physical conditioning, good tactics, etc. A large part of preparation is thinking through possible situations, so your response is almost automatic. The most difficult element in early combat is thinking (just as thinking was difficult on the first training flights). The pilot who can get through this mental barrier and is reasonably lucky will be a success in combat."

"Aggressive but professional - certainly being a good 'stick/throttle' ACM pilot is a must, but equally important is knowing your weapon system thoroughly.' Must have opportunity - many fighter pilots let the other guy take the real tough missions because of fear or lack of confidence."

"Given all things being equal except the individual, it seems to me the most observable quality is the ability to decide when to stand and fight, and when to decide to fight another time. First the desire must be there - it must be overwhelming, but it must be tempered by a common sense (experience, if you will). The situation must be assessed completely because your decision will more than likely be irreversible once committed. For a straight one-on-one, the decision is nothing. As you get more and more airplanes, the situation has to be carefully considered. To me the overwhelming qualities are desire to win - desire to engage, ability and headwork.

"Early in combat - December 1942 - when we arrived in North Africa, we gave our P-38 aircraft to the First and Fourteenth Fighter Groups to restore their losses. With no experience and no tactics resolved, we taught ourselves as best we could with an average of four aircraft per fighter mission. The first 10 missions I flew, we lost 10 pilots. We joked about our odds of returning. We were busy being defensive - always outnumbered. Members of my squadron were registering kills; not me. I got my first kill 3 March after we had grown to 12-ship flights; had settled down with solid tactics; had gained confidence - full throttle was for takeoff. I had progressed from wingman to element leader and, with this kill, became a flight leader - chances became more available. A fighter pilot needs HEART for combat; needs HEAD to know how and when to engage the enemy; needs the HAND (skill and experience) of a professional. Other players can score; but without all three "H's," they only form the other essential ingredient - superiority of numbers when using the best platform(s) available. Select fighter pilots - select the best fighter pilots to lead at each echelon - many a good fighter pilot got lost flying the wing of a senior who didn't have the heart or head to lead preflight. In the beginning of my combat, I guess mentally I had with our odds - three chances to survive - only one to fail. Since I did not question authority, how could I lose? Yet, because of my report on a mission's effectiveness, continued missions of this type were discontinued."

3.6.3 Ratings of the Personal Attributes of an Ace - As a result of our early interviews and a review of the popular literature, 12 personal characteristics of aces were identified for inclusion in our Pilot Effectiveness Questionnaire. These characteristics consisted of the desire to achieve, aggressiveness, courage, determination, endurance, initiative, leadership, team cooperativeness, willingness to take calculated risks, physiological stress tolerance, psychological stress tolerance, and anxiety tolerance. This listing is representative of those personal characteristics which the pilots interviewed and the popular literature deemed to be important. It is not an exhaustive listing of all those personal characteristics which may play an important role in determining who is a combat effective pilot. As can be seen in Figure 3.6-3, most of the pilots responding to our questionnaire rated all of these personal characteristics as being important, very important, or critical for success in combat. Approximately 85% of the pilots answering this questionnaire rated desire to achieve, aggressiveness, and determination as being critical or very important personal characteristics. The factors of courage, initiative and willingness to take calculated risks were rated critical and very important by almost as many pilots. Initiative, leadership, physiological stress tolerance, psychological stress tolerance, and anxiety tolerance all received relatively low ratings, with respect to the other five personality characteristics. However, it should be pointed out that all characteristics listed were considered to be important; some simply were rated as more important than others in the opinion of the pilots polled. The pilot input with respect to the relative importance of these personal characteristics will be used in Section 4 as one of the ways of determining which characteristics are important in the combat effective pilot profile.

9-1152

PERSONAL CHARACTERISTICS	CRITICAL	VERY IMPORTANT	IMPORTANT	FAIRLY IMPORTANT	NOT IMPORTANT
DESIRE TO ACHIEVE	43.3	41.3	12.4	2.4	0.6
AGGRESSIVENESS	46.4	41.7	7.9	3.2	0.9
COURAGE	32.6	40.9	19.7	5.0	1.8
DETERMINATION	41.9	44.6	12.6	0.9	0.0
ENDURANCE	14.8	42.3	31.4	9.5	2.1
INITIATIVE	33.3	47.3	15.8	3.0	0.6
LEADERSHIP	16.7	35.2	34.0	10.5	3.7
TEAM COOPERATIVENESS	17.5	40.1	30.6	9.8	2.1
WILLINGNESS TO TAKE CALCULATED RISK	33.4	35.8	17.3	11.7	
PHYSIOLOGICAL STRESS TOLERANCE	21.1	37.1	30.3	10.1	1.5
PSYCHOLOGICAL STRESS TOLERANCE	27.5	39.5	25.1	6.0	1.8
ANXIETY TOLERANCE	22.2	35.0	28.1	13.2	1.5

FIGURE 3.6-3 PILOT OPINION OF IMPORTANCE OF SELECTED PERSONAL CHARACTERISTICS – PERCENT OF PILOTS RESPONDING UNDER EACH LEVEL OF IMPORTANCE

3.6.4 Ratings of the Importance of Critical Combat Pilot Skills - Data on the relative importance of a number of combat skills were also obtained from the Pilot Effectiveness Questionnaire. A preliminary task analysis of air-to-air combat, interviews with a number of pilots, and the inputs from trained pilot psychologists yielded a list of nine critical skills and abilities which would be required of the effective fighter pilot. The pilots receiving the questionnaire were asked to rank the top five of these skills and abilities according to their relative contribution to success in combat. A list of these nine skills and abilities and a score reflecting the median ranking obtained from the pilots returning the questionnaires are presented in Figure 3.6-4.[1] In the figure, a score of five corresponds to a median

[1]A median rating, as used in Figure 3.6-4, is calculated as in the following example. If "judge when to shoot" had been ranked by five persons and the rankings were 4th, 5th, 3rd, 5th, and 5th most important, the corresponding rating scores would be 2, 1, 3, 1, and 1. If these scores are then rearranged so they are in ascending order (1, 1, 1, 2, and 3) and the middle score (1) is selected, this would be the median rating from this set of scores.

9-1151

STATEMENT: CERTAIN FLYING, PERCEPTUAL AND JUDGMENTAL SKILLS/ABILITIES DISTINGUISH EFFECTIVE FROM NON-EFFECTIVE FIGHTER PILOTS. AS A PROVEN EFFECTIVE PILOT WE WOULD LIKE YOU TO HELP IDENTIFY WHICH SKILLS/ABILITIES YOU FEEL WERE MOST IMPORTANT IN ACHIEVING COMBAT KILLS. FROM THE LIST BELOW CHOOSE THE FIVE (5) SKILLS/ABILITIES THAT IN YOUR JUDGMENT CONTRIBUTED MOST TO YOUR SUCCESS AND RATE THEM IN ORDER OF IMPORTANCE.

ABILITY TO:	MEDIAN RATINGS*
1. OBTAIN EARLY VISUAL TARGET ACQUISITION.	5
2. PERCEIVE/JUDGE TARGET DIRECTION AND RATE OF TURN, ASPECT ANGLE, ANGLE OFF, TRACK CROSSING ANGLE, RANGE, CLOSING RATE, TRACK CROSSING RATE.	1
3. KEEP TRACK OF YOUR CRITICAL FLIGHT PARAMETERS (AIRSPEED, ALTITUDE, ATTITUDE, ANGLE OF ATTACK, "G")	0
4. SELECT AND EXECUTE THE BEST MANEUVER TO GAIN A FIRING POSITION (LEAD/LAG PURSUIT, YO YO, BARREL ROLL, ETC.).	3
5. JUDGE WHEN TO SHOOT.	1
6. SHOOT WELL (BOTH TRACKING, OR RAKING SHOT WHEN TRACKING WAS IMPOSSIBLE).	0
7. HANDLE THE THROTTLE(S) AND SPEEDBRAKE (MANAGE ENERGY).	0
8. KEEP TRACK OF THE OTHER GUYS - YOUR WINGMAN, OTHER HOSTILES.	1
9. JUDGE WHEN TO LEAVE THE FIGHT.	0
10. OTHER	0

*THE HIGHER THE RATING VALUE THE MORE IMPORTANT THE SKILL. A ZERO RATING MEANS IT WAS NOT SELECTED AS IN THE TOP FIVE BY OVER ONE-HALF OF THE PILOTS RESPONDING.

FIGURE 3.6-4 MEDIAN RATINGS OF CRITICAL COMBAT PILOT SKILLS

ranking of first place and a score of one corresponds to a fifth place median ranking. The five skills and abilities which have a nonzero median rating were chosen by more than half of the pilots as being among the five most important skills or abilities for air-to-air combat effectiveness.

The most surprising result of this set of ratings was the fact that a perceptual ability, and not a flying skill, appeared to be the most important single determiner of achieving combat effectiveness. This perceptual skill, "Obtaining early visual target acquisition," received the highest possible rating in over half of the cases. Next in importance was the ability to select and execute the best maneuver to gain a firing position. Following this were: The ability to perceive and judge target direction; rate of turn and aspect angle and other flight parameters; judging when to shoot; and keeping track of the other participants in the engagement - your wingman and/or other hostiles. Factors such as: Keeping track of the critical flight parameters; shooting well; managing energy; and judging when to leave the fight were not considered important enough to be rated amont the top five by over half of the pilots returning the questionnaire. While these skills and abilities are important to the overall outcome of a combat engagement, they are not as important as the other characteristics listed. Like the ratings of aces listed in subsection 3.6.3, the skills and abilities identified as being critically important in this section will be used as inputs for our development of the combat effective pilot profile.

3.6.5 Summary - Pilot inputs arising from three sources, the popular literature, narrative comments by aces, and questionnaire responses from 373 fighter pilots, were evaluated. Additionally, a representative sample of pilot comments was presented.

Although anecdotal in nature, the popular literature provided a background for the comments from the aces. An analysis of comments made by the aces yielded 30 descriptors which included aggressiveness, visual ability, self-confidence, risk-taking ability, and leadership. (The complete list appears in Figure 3.6-2.) Two questions from the Pilot Effectiveness Quesionnaire provided information on the personal attributes and critical skills required for effective air-to-air combat performance. The pilots sampled rated desire to achieve, aggressiveness, and determination as the most critical personal attributes. They overwhelmingly rated ability to obtain early visual target acquisition as the most important pilot skill factor for air-to-air effectiveness.

4.0 PROFILE OF THE COMBAT EFFECTIVE PILOT

Figure 4.0-1 presents a summary of information that was reviewed in Sections 3.2 through 3.6 regarding the critical attributes of the combat effective. Predictors were grouped into 12 major domains with 53 subcategories or factors.[1] Inputs to this matrix were developed from five sources:

From Section 3.2 - Scientific studies related to aviation combat using both objective (e.g., number of kills) and subjective (e.g., peer and supervisor ratings) measures.

From Section 3.3 - Scientific studies related to nonaviation combat (primarily infantry) using subjective (e.g., peer and supervisor ratings) measures.

From Section 3.4 - Scientific studies related to success in aviation training using a pass-fail criterion.

From Section 3.5 - Reports of foreign aviation selection programs.

From Section 3.6 - Analysis of pilot opinions drawn from our specially developed Pilot Effectiveness Questionnaire.

Using these sources, each of the 51 factors were rated with respect to their relative importance for selection. With the first three sources, these ratings were principally based upon the magnitude of the highest correlation reported. Predictors (factors) were rated as Unimportant (X) if the highest correlation was below .15, Important (XX) if the highest correlation was between .15 and .39, and Very Important (XXX) if the highest correlation was .40 or above. These cutoffs are arbitrary, but serve to group the empirical data into three interpretable categories.

Ratings derived from the foreign selection data were based upon the frequency of predictor usage and the importance placed upon predictors in the current Israeli program as well as in the World War II Japanese and German programs. Ratings derived from pilot opinions were based upon the responses of 100 or more fighter pilots to three questions from the Pilot Effectiveness Quesionnaire. Two of the questions required pilots to rank predictors with respect to their relative importance for the selection of fighter pilots. The third involved pilot responses to an open-ended question concerning the qualities of an ace.

In the last column of Figure 4.0-1 is a summary of the current United States Air Force (USAF) selection program. Checkmarks indicate the characteristics and critical skills which are used as the basis for selection tests for entrance into undergraduate pilot training (UPT). These decisions are based upon our own assessment of the selection routine, including a detailed review of the AFOQT.

This matrix is used to generate hypotheses regarding the characteristics and critical skills of the combat effective pilot which are discussed in subsections. With this goal in mind, the 12 domains were subdivided into two categories (see Figure 4.0-1). This subdivision was primarily based upon three factors:

a. How frequently predictors within each domain were validated against combat criteria.

b. The quality of the combat validation studies within each domain.

c. The strength of relationship between the predictors within each domain and combat criteria.

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[1] We realize that, in some cases, the factors listed in Figure 4.0-1 appear to be overlapping (e.g., performance under stress and ability to withstand psychological stress). If the next phase of this program is implemented, factors which cannot be operationally distinguished will be grouped.

	CHARACTERISTICS AND CRITICAL SKILLS	SOURCE: AVIATION COMBAT – OBJECTIVE MEASURES	AVIATION COMBAT – SUBJECTIVE MEASURES	NONAVIATION COMBAT – SUBJECTIVE MEASURES	AVIATION TRAINING – PASS–FAIL	FOREIGN AVIATION SELECTION	PILOT OPINION	U.S.A.F. PILOT SELECTION
CHARACTERISTICS AND CRITICAL SKILLS WITH DEMONSTRATED VALIDITY IN COMBAT SITUATIONS	BIOGRAPHIC DATA							
	• LIFE INVENTORY	X X X	X	X X	X X	X X	X	√
	• ACADEMIC HISTORY	X X X	X X	X X	X X X	X		√
	• MILITARY HISTORY	X X X		X X	X X X	X X	X	
	• MILITARY RANK	X X X	X	X X	X X X			
	RISK TAKING							
	• WILLINGNESS TO TAKE CALCULATED RISK	X X X		X X X			X X X	√
	REACTIONS TO STRESS							
	• PERFORMANCE UNDER STRESS	X X		X		X X X	X X X	
	• EMOTIONAL CONTROL	X X X		X		X X	X X X	
	• ABILITY TO WITHSTAND PSYCHOLOGICAL STRESS		X X	X	X X X	X X X	X X X	
	• ANXIETY TOLERANCE			X		X X	X X X	
	SENSORY-MOTOR ABILITIES							
	• VISUAL					X X X	X X X	√
	• MOTOR COORDINATION	X X X	X	X X	X X X	X X X	X	
	• SPATIAL ORIENTATION	X X	X		X X	X X X	X X X	
	• SPATIAL-PERCEPTUAL ABILITY	X		X X	X X	X X X	X X X	√
	• PERCEPTUAL SPEED	X X	X X	X X	X X X	X X	X X	
	APTITUDE							
	• PILOT COMPOSITES	X X X	X		X X X	X X X		√
	• NON PILOT COMPOSITES	X X	X	X X X	X X X			√
	• GENERAL APTITUDE (INTELLIGENCE)	X X		X X	X X X	X X	X X	√
	• NUMERICAL SKILLS	X X	X X	X X X	X X	X X		√
	• VERBAL SKILLS	X X X	X	X X X	X X	X		√
	• MECHANICAL SKILLS	X X	X	X X X	X X X	X X	X	√
	• FLIGHT APTITUDE		X	X X X	X X X	X X X	X X	√
CHARACTERISTICS AND CRITICAL SKILLS IDENTIFIED FROM AVIATION TRAINING RESEARCH, FOREIGN SELECTION POLICY, AND PILOT OPINION	PERSONALITY							
	• AGRESSIVENESS	X X X				X X X	X X X	
	• CONFIDENCE					X X X	X X	
	• MENTAL HEALTH	X X			X X X	X X	X	√
	• CONSIDERATION FOR OTHERS		X X X			X	X	
	• PERSONALITY STYLE	X	X X	X X	X X X	X	X	√
	• COURAGE					X X	X X X	
	PERSONALITY – LEADERSHIP							
	• RESPONSIBILITY FOR MEN IN COMBAT		X X				X X	
	• PHYSICAL AND COMBAT LEADERSHIP			X		X	X X	
	• ADMINISTRATIVE SKILLS		X X	X X			X	
	• MILITARY BEARING	X	X X	X		X X	X	
	SOCIAL FACTORS							
	• TEAMWORK		X X X			X	X X	
	• SOCIABILITY	X X		X X		X X	X	
	• GROUP LOYALTY			X		X	X X	
	• INTERPERSONAL RATING			X X X	X X	X X	X	
	MOTIVATION							
	• DETERMINATION/DESIRE	X X X				X X X	X X X	
	• SELF DISCIPLINE	X X	X X			X X	X X	
	• SATISFACTION		X X	X X	X X		X	√
	MEDICAL/PHYSIOLOGICAL							
	• GOOD PHYSICAL HEALTH			X		X X X	X	√
	• ENDURANCE			X		X X	X X	
	• PHYSICAL APTITUDE			X	X	X X	X	
	• ABILITY TO WITHSTAND PHYSIOLOGICAL STRESS				X	X	X X	
	DECISION MAKING/INFORMATION PROCESSING							
	• SELECTIVE ATTENTION		X	X X	X X	X X	X X X	
	• DECISION TIME		X X	X X		X X X	X X X	
	• QUALITY OF COMBAT DECISIONS			X X			X X X	
	• ALERTNESS			X X		X X	X X X	
	• INTEGRATIVE DECISIONS	X	X	X X		X	X X	
	AVIATOR SKILLS, KNOWLEDGES, AND TASKS							
	• EQUIPMENT KNOWLEDGE	X	X X		X X	X	X X X	√
	• FLIGHT SKILLS	X	X X		X X X	X X X	X X	√
	• INSTRUMENT READING	X X	X X		X X X	X X	X	√
	• AERIAL GUNNERY					X X	X X	

FIGURE 4.0-1 A SUMMARY OF CHARACTERISTICS AND CRITICAL SKILLS FOR THE COMBAT EFFECTIVE. THESE DATA ARE USED TO GENERATE HYPOTHESES REGARDING THE CRITICAL ATTRIBUTES OF THE COMBAT EFFECTIVE FIGHTER PILOT.

Five of the domains contain predictors which have been preliminarily validated against combat criteria (Biographical Data; Risk Taking; Reactions to Stress; Sensory-Motor Abilities; and Aptitude). These domains are discussed in Section 4.1. As shown in Figure 4.0-1, many of these predictors have been validated against success in training. An implicit assumption in this research is that there is a high degree of relatedness between success in training and success in combat. However, this assumption need not hold (see Section 3.2.1). Therefore, hypothesis construction in these five domains is based upon combat research and not training research.

The other seven domains contain predictors which have been identified from aviation training research, foreign selection policy, and pilot opinion (Personality, Personality-Leadership, Social Factors, Motivation, Medical/Physiological, Decision Making/Information Processing; and Aviator Skills, Knowledges, and Tasks). These domains are discussed in Section 4.2. Since these predictors have not been adequately validated against combat criteria, aviation training research is drawn upon for hypothesis construction when available.

In subdividing these domains, it is not our intent to imply that predictors within these two domain categories differ with respect to their potential value for the prediction of the combat effective pilot. A distinction of this type would be faulty since many of the predictors which have not been studied in the combat situation present challenging measurement problems.

4.1 CHARACTERISTICS AND CRITICAL SKILLS WITH DEMONSTRATED VALIDITY IN COMBAT SITUATIONS

4.1.1 Biographical Data - "Biographical data" is a special domain in that it is not really a characteristic but reflects historical information about this individual as well as constant biographical facts. A characteristic tested at the actual time of pilot selection would be categorized as that characteristic; but earlier or historical manifestations of that characteristic noted at the time of selection would be treated as biographical data. For example, information on childhood aggressiveness provides biographical data whereas aggressiveness, per se, is a personality characteristic and will be discussed in subsection 4.2.1.

For the present purposes, biographical data tend to be of three basic types, life inventory, academic history, and military history. Various classes of biographical data have been shown to be related to combat effectiveness in both aviation and nonaviation settings. Studying the combat effectiveness of infantrymen with disciplinary problems, Dubuisson and Klieger (1964) found that a personal inventory predicted combat ratings of effectiveness fairly well. Looking at infantrymen in Korea, Willemin and Karcher (1958) found that a classification inventory was predictive of combat ratings.

General or global scales from biographical inventories and biographical data blanks have not shown particularly strong relationships in aviation combat studies (Jenkins, Ewart and Carroll, 1950; Torrance, Rush, Kohn, and Doughty, 1957; Lepley, 1947), but specific scales from those biographical questionnaires have yielded data suggesting that this approach is extremely valuable. Specific factors, including independence training, family moving, parental control, and childhood aggressiveness, emerged as related to combat kills in the Strawbridge and Kahn (1955) and Torrance, et al, (1957) studies. It appears that if the right life inventory questions are asked, the prediction of combat effectiveness may be quite good.

Academic history questions also appear to be related to combat effectiveness. Grades and class standing at West Point have been shown to be related to combat performance ratings (King, Campbell, Johnson, Klieger, and Yaukey, 1952). Similarly, OCS grades have correlated with Officer Efficiency Reports given for combat service (Katter and Holmon, 1955). Selected military history items, particularly flying hours in various types of planes,

have been shown to be related, in varying degrees, to combat flying performance (Torrance, et al, 1957; Strawbridge and Kahn, 1955).

In general, biographical data have been shown to be related to combat effectiveness. This is interpreted as a demonstration of selection test potential for this class of predictor variable. Indeed, the present writers were so convinced of the potential of life inventory data as one tool for predicting combat effectiveness that the Pilot Life Inventory Questionnaire (Short Form) was developed and administered to hundreds of pilots in a preliminary questionnaire refinement effort.[2]

Scientific studies of combat effectiveness confirm the potential utility of biographical data for predicting combat effective fighter pilots. Also, pilot opinion and use in foreign selection programs suggest that this is a fruitful domain for further development. Two brief sections of the AFOQT include biographical data, but there is room for substantial expansion. After all, the AFOQT has been validated on training performance, not on combat performance.

4.1.2 Risk Taking - Risk taking behavior was studied by Torrance and Ziller (1957). They found that a specially devised risk scale correlated positively with two measures, Test Risk and Perceived Risk, taken in a combat surrogate, survival school, environment. The development of the risk scale came after statistically significant relationships between a life inventory risk scale and combat success (becoming an ace) had been shown (Torrance, et al, 1957). It should be noted here that even though very strong relationships between risk taking and certain criterion measures have been shown, only a limited and possibly inadequate testing approach (paper-and-pencil testing) has been used. Pilot opinion has strongly supported risk taking as critical, and this characteristic is currently only indirectly tested for in the USAF pilot selection program through methods such as questions about automobile driving behavior. Risk taking, as a behavioral characteristic, appears very important and should be more thoroughly explored.

4.1.3 Reactions to Stress - Evidence from observations of performance in stressful situations suggests that differences in handling stress might prove to be important for distinguishing between good and poor pilots. Conclusions of a participant observer indicate that performance in stressful situations undoubtedly can be used as a measuring dimension (Peres, 1959). Strawbridge and Kahn (1955) found that performance on an aiming stress test correlated well with objective aviation combat criteria. Additionally, Roff (1950) found, and it was no surprise, that good pilots were described as having greater tolerance for stress than poorer pilots when aviators were asked at the end of a combat tour to describe other pilots.

A different aspect of the stress reaction domain is emotional control. Torrance, et al, (1957) noted that a significant difference exists in the amount of emotional reaction expressed during combat encounters when aces' and nonaces' self reports were compared. Aces showed less emotion.

In addition to the indications from the combat and combat surrogate studies, pilots we surveyed strongly supported positive reactions to stress as a component of any accurate profile of the combat effective aviator. Also, descriptions of the Israeli pilot selection program suggest that this is an important domain. Clearly, further investigation of the relationship between reactions to stress and combat performance is warranted.

[2]A description of the development and preliminary results from the Pilot Life Inventory Questionnaire (Short Form) is given in Section 5.

4.1.4 Sensory-Motor Abilities - Several dimensions of sensory-motor abilities have been evaluated in aviation combat studies and shown to be of value in predicting superior aviators. Motor coordination (tests of two hand coordination, finger dexterity, rudder control, complex coordination, and rotary pursuit performance) was shown to correlate with World War II measures of combat performance including ratings of flying proficiency, completion of a combat tour, and several bombing accuracy measures (Lepley, 1947). Selected coordination measures, most notably rotary pursuit performance, were positively correlated with combat kills in two Korean War Studies (Strawbridge and Kahn, 1955; Torrance, et al, 1957).

Spatial orientation measures demonstrated a strong relationship with completing a fighter pilot combat tour but only a very weak relationship with other combat measures taken in World War II (Lepley, 1947). In the same research effort, reaction time and other perceptual speed measures were useful for predicting some measures of bomber crew performance.

Relationships between perceptual-motor performance and rated performance from infantry combat and combat surrogate settings suggests that this category of variable is important for other combat roles as well as that of the pilot (e.g., Willemin and Karcher, 1958).

During World War II, and for some years after that, the USAF employed psychomotor testing as part of its selection program, but for several reasons, including the difficulties associated with test administration and equipment calibration in multiple locations, this was given up. Recently efforts have been made in the direction of developing psychomotor (McGrevy and Valentine, 1974; Sanders, Valentine and McGrevy, 1971) and information processing tests (Pew and Adams, 1975) for pilot selection. Nevertheless, the USAF selection program does not, at present, include this sort of testing, even for the prediction of success in flight training.

Foreign selection programs and pilot opinion strongly endorse the predictive potential of tests of sensory-motor abilities. In light of encouraging scientific data and the widespread belief that pilots require an above average level of sensory-motor ability, the importance of work to develop and validate tests in this domain (against ACMR and combat performance) is self-evident.

4.1.5 Aptitude - Aptitudes have been successfully used to predict objective measures of aviation combat success. For our purposes, the aptitude testing domain is defined broadly so as to include intelligence tests and composites, e.g., stanines.

Pilot stanine scores were related to retention in the fighter pilot program and to bombing accuracy in World War II (Lepley, 1947). In Korea, these scores were related to combat kills in the sample of fighter pilots studied by Torrance, et al, (1957). In contrast to this, Strawbridge and Kahn (1955) obtained a .00 correlation between pilot stanine and number of kills in their Korean sample.

Aptitude tests for military roles other than that of the pilot have also been evaluated. Stanines of other aviator specialites (e.g., bombardier, navigator) yielded less conclusive results than would be expected when administered to pilots. The value of special job area aptitude tests for non-flying combatants was supported by the results of the Army Personnel Research Branch findings which related aptitude area scores to combat aptitude ratings and rated combat performance (e.g., Willemin, Rosenberg, and White, 1957; Birnbaum, White, Rosenberg, and Willemin, 1957).

General aptitude and intelligence tests were valuable in the Korean HumRRO work (Egbert, Meeland, Cline, Forgy, Spickler, and Brown, 1957), and a general information test was significantly correlated with the number of combat kills in a study of Korean aviators (Strawbridge and Kahn, 1955). The traditional verbal and numerical aptitude areas have been useful for selecting pilots. Numerical operations

tests and reading comprehension tests were inversely related to objective criteria of combat success in World War II and in the Korean War (Lepley, 1947; Torrance, et al, 1957). Scores on a mechanical aptitude test were positively related to the number of kills in Korea (Torrance, et al, 1957).

Pilot opinion did not strongly support aptitude testing for selecting pilots. Despite this, a very strong case for the use of aptitude tests exists. Undoubtedly, general and special aptitude tests can be improved, but moderately strong devices are currently available and are being used in the present USAF selection program. Because of the broad based scientific support for aptitude testing, it seems imperative that it be included in the next generation of pilot selection instruments.

4.2 CHARACTERISTICS AND CRITICAL SKILLS IDENTIFIED FROM AVIATION TRAINING RESEARCH, FOREIGN SELECTION POLICY, AND PILOT OPINION

4.2.1 Personality - Six major types of variables were identified in this domain. These are aggressiveness, self-confidence, mental health, consideration for others, personality style, and courage. Of these variables, those which seem to show the most potential for the prediction of the combat effective fighter pilot are aggressiveness, self-confidence, courage, and personality style.

Within combat-related research, measures of adult aggressiveness have not been studied. However, childhood aggressiveness, which is a biographical variable (see Section 4.1.1), has shown strong relationships with measures of air superiority. In two of the best studies conducted during the Korean War, high correlations were found between childhood fighting and the number of combat kills (Torrance, et al, 1957; Strawbridge and Kahn, 1955). Additionally, fighter pilots rated aggressiveness[3] as among the most critical characteristics of the combat effective air superiority fighter pilot, and this variable plays a major role in foreign selection programs. The fact that aggressiveness is not currently tested for in the selection of military aviators may reflect the fact that it is difficult to measure rather than the fact that it is not understood to be an important factor in combat effectiveness.[4] Very careful consideration should be given to constructing tests which have the potential for measuring this factor.

Self-confidence and courage are two other factors which in our opinion should be highlighted in developing an expanded fighter pilot selection program. We encountered no research in pilot selection which directly evaluated these variables as characteristics of the combat effective. However, pilots regarded these, especially self-confidence, as important for selection, and both factors play a major role in foreign selection programs. We feel that a pilot's confidence in his performance in fighter aircraft and his courage should be important indicants of his willingness to engage the enemy. Therefore, some appropriately developed measures of self-confidence and courage in a selection program seem justified.

Personality style has been studied somewhat in combat situations, and data suggest that this variable is a potentially valid one. For example, in a survey of combat pilots leaving Korea, the most effective pilots were given personality descriptors such as modest, enthusiastic, sincere, and even-tempered (Roff, 1950). The U.S. Army Personnel Research Branch Psychologists (e.g., Willemin and Rosenberg, 1957b) correlated responses on personality tests with rated effectiveness of soldiers in Korea and found moderately high validity coefficients. Personality style is also reported to be of value in predicting success in training. Trexler (1969), for example, found significantly lower ego identity scores among failures than among successful flight candidates. Therefore, although pilot opinion regarding personality style is low and foreign selection programs place little importance on it, empirical data are suggestive of its potential value for the prediction of combat effectiveness. We recommend that some measure of this factor be refined for use in pilot selection for combat effectiveness.

For somewhat different reasons, mental health and consideration for others do not seem to warrant any further development or attention. Torrance, et al, (1957) noted that exhibiting childhood neurotic traits was inversely related to being an ace. However, this factor is a biographical one and not a mental health variable per se (see Section 4.1.1). Studies attempting to predict combat effectiveness have rarely addressed mental health in adults.

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[3]When pilots use the word aggressiveness, they are apparently referring to a set of behaviors associated with attacking the enemy, a behavior we want to predict.

[4]This comment also applies to other variables discussed in this section. Another good example is courage.

However, when it has been addressed, puzzling results are sometimes reported. For example, Sparks and Neiss (1956; In Mebane, 1957), report a correlation of -.43 between psychiatric ratings and ratings of combat effectiveness. Although this correlation is substantial, it is in the wrong direction. Coupled with this, pilots considered mental health to be relatively unimportant as a testing area. Perhaps the latter is influenced by the long time presence of screening for mental health in the U.S. system, i.e., those with "poor mental health" have been removed. Generally, it appears that mental health is important for initially screening out inappropriate persons, and the current USAF program seems to be adequate in this respect, particularly if the ARMA is used.

There is little reason for recommeding consideration for others as a variable for a pilot selection program. Hemphill and Sechrest (1952) found this factor important for bombing crews. However, it seems that consideration for others would be more critical in the bombing setting than in the fighter plane setting. Furthermore, pilots rated this factor as relatively unimportant for selection, and foreign selection programs place little importance upon it. Therefore, consideration for others is not thought to be worthy of attention in a combat effectiveness selection program. Some related factors are considered in Section 4.2.3 where social factors are discussed.

4.2.2 Personality-Leadership - Factors identified within this domain are responsibility for one's men in combat, physical and combat leadership, administrative skills, and military bearing. Although none of these factors is assessed within the current USAF selection program, two of these seem to be potentially valid for the prediction of fighter pilot combat performance.

Responsibility for one's men in combat is one of these two factors. Roff (1950) found that pilots leaving Korea rated responsibility as a characteristic of the best fighter pilots. Complementing this is the pilot opinion in our study, i.e., responsibility for subordinates in combat was rated as relatively important for fighter pilot selection.

The second personality-leadership factor which merits attention is physical and combat leadership. This factor does not play a major role in foreign selection programs and showed low correlations with nonflying officer behaviors in an Army study (Helme and Grafton, 1975). However, physical and combat leadership was rated as a relatively important characteristic by the fighter pilots. In view of this pilot opinion and the absence of any negative evidence from aviation combat research, we recommend that this factor be considered in a pilot selection program.

Administrative skills and military bearing seem to show little promise as predictors of success in combat. Administrative skills were found to be related to nonflying officer behavior in an Army study (Helme and Grafton, 1975), and fighter pilots leaving Korea rated these skills as characteristics of the best fighter pilots. However, pilots we questioned considered administrative skills to be unimportant for selection. In addition, these skills are only infrequently assessed in foreign selection programs and appear to have little face validity for the selection of the combat effective.

Military bearing rarely showed a meaningful relationship to measures of combat performance. Hemphill and Sechrest (1952) found a relatively high correlation between military bearing and peer nominations for bomber crew performance. However, this factor (measured by Officer Quality) showed little relationship to the number of combat kills in Korea in two studies (Strawbridge and Kahn, 1955; Torrance, et al, 1957), and little relationship to staff performance in a simulated combat environment (Helme and Grafton, 1975). In addition, pilots rated military bearing as relatively unimportant for selection. Therefore, as with administrative skills, this factor is also considered to be of little value for pilot selection.

4.2.3 Social Factors - Four types of social factors have been evaluated. These are teamwork, sociability, group loyalty, and interpersonal ratings. Although none of these factors is currently assessed within the USAF selection system, three seem to merit attention.

Of the social factors considered, interpersonal ratings seem to be the most valid for the prediction of combat effectiveness. Army sponsored research has demonstrated that peer and supervisor evaluations are highly useful both as predictors of and assessments of combat performance (Egbert, et al, 1957; King, et al, 1952). These ratings have also been effective in predicting success in training. Fleischman, Ambler, Peterson, and Lane (1966) found a significant correlation between peer ratings and pass-fail. Similarly, Waag and Shannon (1972) reported relatively high correlations between four instructor ratings and pass-fail. Therefore, although pilot opinion is low and little attention is given to these ratings in foreign selection programs, empirical data lead us to conclude that interpersonal ratings should be seriously considered as a factor in a pilot selection battery.

Aviation combat research suggests that teamwork is a valid predictor of combat effectiveness. Hemphill and Sechrest (1952) related this predictor to both bombing accuracy and peer ratings in combat and found strong relationships. Admittedly, the bomber environment and fighter environment are different, but teamwork seems integral (although in a different manner) to both. Furthermore, pilots noted this factor as a relatively important characteristic of the fighter pilot. Consequently, the development of a test for teamwork seems justified.

Both aviation and nonaviation research indicate that sociability has potential value for the selection of the combat effective. This factor showed relatively strong relationships to the number of kills in Korea (Strawbridge and Kahn, 1955), and to several measures in a specially designed stress environment (Meeland, Egbert, and Miller, 1957). Although pilot opinion of it is low, sociability is often assessed in foreign selection programs. In view of the empirical data and foreign selection policy, this factor is recommended for inclusion in a pilot selection program.

Group loyalty does not seem to warrant any additional attention as a predictor of combat effectiveness. Edgerton and Graham (1951) studied the descriptors assigned to 927 good and poor infantrymen in Korea. Of 12 descriptors in the group loyalty category (e.g., helps others, stuck with me), only one (thoughtful of others) noticeably differentiated good from poor infantrymen. Although pilots rated group loyalty as a relatively important characteristic of the fighter pilot, foreign selection programs place little emphasis upon this factor. Therefore, empirical data and foreign selection policy seem to indicate that group loyalty is not an efficient predictor of combat effectiveness.

4.2.4 Motivation - Of the three types of motivation factors which have been studied (determination/desire, self-discipline, and satisfaction), determination seems to be the most critical for combat effectiveness. This position is supported by high ratings derived from three sources of input. Torrance, et al, (1957) specifically note that more aces had made special efforts to become fighter pilots than nonaces. Complementing this is the finding that pilots rated determination as highly important for selection and the fact that determination plays a major role in foreign selection programs. Since all sources available considered this factor to be a critical one, we recommend that a determination measure be included in a pilot selection program.

Relationships between self-discipline and combat performance have been moderately high. For example, Roff (1950) found that effective Korean fighter pilots were characterized by greater consistency of effort than were less effective pilots. Similarly, aces were reported to have less time on their hands than nonaces (Torrance, et al, 1957). Additional support is provided by pilot opinion

and foreign selection policy. Ratings derived from both sources of input were relatively high. In conclusion, we feel that self-discipline should also be a factor in a pilot selection program.

Relationships between satisfaction (e.g., interests, job satisfaction) and combat performance have also been fairly strong. Special interest in combat-related activities correlated moderately well with staff performance and leadership ratings in a simulated combat environment (Helme and Grafton, 1975). Roff (1950) found that effective Korean fighter pilots were more frequently characterized by enthusiasm than were less effective pilots. Similarly, aces were reported to be more enthusiastic about competition and made more special attempts to fly fighter planes than nonaces (Torrance, et al, 1957). In some cases, moderately high correlations have also been found when interests were related to success in training. For example, Valentine (1961) reported substantial correlations between two AFOQT interest scores (Flying Interest and Technical Interest) and pass-fail in primary training. However, correlations with pass-fail in basic training were low indicating that these particular interest measures may have limited potential. Therefore, even though ratings derived from pilot opinion and foreign selection policy were low, empirical data support the conclusion that satisfaction measures are potentially valid for the prediction of combat effectiveness. Although the AFOQT contains several interest measures, training data indicate that further refinements are desirable.

4.2.5 Medical/Physiological - Physical health is assessed in both foreign selection programs and in the USAF system. We encountered no combat or training research which evaluated this factor, and pilots regarded improvements in this area of selection as unnecessary. The latter could be influenced by the presence of screening for physical health in the United States military, i.e., those with "poor physical health" are eliminated. Therefore, it appears that physical health is important for initially screening out unhealthy individuals, and the USAF system seems adequate in this respect.

Of the remaining types of factors within this domain (endurance, physical aptitude, and ability to withstand physiological stress), only ability to withstand physiological stress seems to warrant serious consideration. We found no combat research which evaluated this factor, and training data are disappointing. For example, Ambler and Guedry (1968) related responses to a Brief Vestibular Disorientation Test (rotating chair) to pass-fail in training. Although the correlation was statistically significant, it was quite low ($r = .14$). Additionally, foreign selection programs place little importance upon this factor. However, we still feel that measurement of physiological stress reactions is justified, i.e., it seems that ability to withstand physiological stress should be related to fighter pilot effectiveness. Pilots we questioned appear to agree since they rated this factor as important for selection. In the absence of any disconfirming evidence from combat research, we recommend that physiological stress tests be included in a pilot selection program.

There is little reason for recommending the inclusion of endurance and physical aptitude tests per se in the USAF selection program.[5] Although both of these factors are assessed in foreign selection programs and pilots considered endurance to be important for selection, neither has demonstrated validity. Helme and Grafton (1975) found that endurance was unrelated to staff performance and leadership ratings in a simulated combat environment. Similarly, physical fitness is reported to be uncorrelated with success in combat (Willemin and Rosenberg, 1957) and with success in training (Valentine, 1961).

4.2.6 Decision Making/Information Processing - Factors which can be reasonably classed under a decision making/information processing domain have not been adequately evaluated in aviation combat settings. Choice reaction time measures were taken

[5]However, endurance tests in particular and physical aptitude tests with an endurance component might well be recommended as tests for determination.

in the World War II program, but strong predictive value was not substantiated. Lepley (1947) found only nonsignificant correlations between "reading and judgment" skill and ratings of overall effectiveness. Similarly, Korean War researchers failed to find a relationship between "judgment" and objective measures of combat effectiveness (Strawbridge and Kahn, 1955; Torrance, et al, 1957). Information processing theories have developed substantially since the early 1950s; this has been accompanied by considerable research on decision making (related to both speeded decisions and deliberate decisions). This is partly an outgrowth of the interest generated in applied psychology during World War II.

A sound theoretical and experimental base now exists for expanding this class of variable into highly useful tests (see, for example, Broadbent, 1971; Kahneman, 1973; Teichner and Krebs, 1974). In conjunction with their review and development of motor skills tests pertaining to pilot selection, Pew and Adams (1975) have examined some information processing tests. This reflects a growing interest in applying this class of variable to pilot selection for success in pilot training. We view it as an important predictor of combat success.

Nonaviation research has looked at several decision making/information processing factors. Support for perceptual speed studies is reported with the sensory-motor data. Several Army Personnel Research Branch researchers found moderate relationships between reasoning tests and combat aptitude ratings (Birnbaum, White, Rosenberg, and Willemin, 1957a; Birnbaum, Rosenberg, White and Willemin, 1957; Willemin, Rosenberg, and White, 1957; Willemin and Rosenberg, 1957). The same reasoning tests were compared with actual combat ratings, and a moderate relationship was found (Willemin, Birnbaum, Rosenberg, and White, 1957). A test of intelligence and alertness showed a relationship with peer ratings in a study by Edgerton and Graham (1951). Generally, nonaviation combat research has indicated that decision making/information processing is a valuable domain.

High quality, fast combat decision making was cited by pilots questioned by Roff (1950) as a characteristic of good pilots. This is consistent with the high potential value the pilots we questioned were willing to assign to decision time, selective attention, and quality of combat decisions.

Most of the support for an expanded effort in the domain of decision making/information processing comes from pilot opinion. This support, when augmented by the recently improved theoretical base for developing tests in this area, makes it a domain worthy of further analysis and research.

4.2.7 Aviator Skills, Knowledges, and Tasks - Included in this domain are predictors related to equipment knowledge (e.g., aeronautical information, technical vocabulary), flight skills (e.g., job sample and light plane performance, visualization of maneuvers), instrument reading (e.g., dial and table reading, instrument comprehension), and aerial gunnery. Three of these factors (equipment knowledge, flight skills, and instrument reading) are assessed within the current USAF selection program.

Torrance, et al, (1957) found low correlations between equipment knowledge (technical vocabulary; pilot) and number of kills in Korea. However, pilots leaving Korea rated knowledge of equipment as a skill of the best fighter pilots (Roff, 1950), a finding which is complemented by pilot opinion in our study, i.e., fighter pilots considered this factor to be highly important for selection. Training data also support the importance of this factor. For example, Kaplan (1965) reported moderately high correlations between aeronautical information and the pass-fail criterion.

A similar pattern emerges with flight skills. Hemphill and Sechrest (1952) found little relationship between flight skills and peer nominations in bombing crew performance. However, pilots rated the possession of flight skills as an important attribute

of the best fighter pilots in Korea (Roff, 1950). Similarly, pilots we questioned considered flight skills to be relatively important for selection. Training data strongly suggest that this factor is measurable. Moderately high to high correlations have been found between pass-fail and flight grades (Flyer and Bigbee, 1955b; Martoccia and Nelson, 1956), job sample performance (Lemaster and Gray, 1974; Long and Varney, 1975), light plane performance (Berkshire and Ambler, 1963; Flyer and Bigbee, 1955a, 1955b; Mullins and Cox, 1960), flight visualization (Kaplan, 1965), and visualization of maneuvers (Valentine, 1961), respectively.

During World War II, low correlations were reported between instrument skills and objective and subjective criteria with one exception. A statistically significant negative correlation was found between dial and table reading and circular error in bombing (Lepley, 1947). Also noted are low and moderate relationships between instrument skills and number of combat kills in Korea (Strawbridge and Kahn, 1955; Torrance, et al, 1957). This factor was also considered to be unimportant by pilots we sampled. In contrast, foreign selection policy strongly suggests measurement of instrument reading as does training research (DuBois, 1947; Kaplan, 1965; Valentine, 1961). For example, correlations of .34 to .46 were reported between instrument reading and pass-fail during World War II (DuBois, 1947).

Although few data are available for aerial gunnery, both pilot opinion and foreign selection policy suggest that this factor be included in a pilot selection program.

In conclusion, demonstrated competence in performing components of a complex task should be related to success in performance of that task. Aviator skills, knowledges, and tasks would, all factors being equal, be expected to be more closely related to aviation combat performance than other classes of predictors. Generally, relationships reported in aviation research have been weak. Perhaps this is due in part to the insensitivity in the measuring devices used. In contrast, moderate to high correlations were noted in the training research, a finding which is often complemented by pilot opinion and foreign selection policy. In view of the latter and the face validity of aviator skills, knowledges, and tasks, these measures are judged to be important for the selection of the combat effective.

4.3 SUMMARY OF THE CHARACTERISTICS AND CRITICAL SKILLS FOR THE PREDICTION OF THE COMBAT EFFECTIVE FIGHTER PILOT

In Sections 4.1 and 4.2, the characteristics and critical skills which comprise a profile of the combat effective fighter pilot were discussed. Figure 4.3-1 presents an overview of these sections.

As can be seen from the figure, six of the 51 factors were not recommended for testing. Of the 45 factors which were recommended for testing, ten appear to be adequately tested within the current United States Air Force pilot selection program. To select fighter pilots adequately, the 35 factors listed in the last column of this figure require further analysis. These factors must be exhaustively analyzed and developed specifically for the purpose of selecting the combat effective. Section 7 contains our evaluations of the available testing devices as they pertain to these characteristics and critical skills.

Prior to these evaluations, specific testing procedures which have been more thoroughly considered are discussed. Section 5 presents the development of a paper-and-pencil life inventory questionnaire which has potential for selecting combat effective fighter pilots. Section 6 summarizes the state of the art in air combat simulation. Both of these sections include information which impacts the assessment of the various testing domains discussed in Section 7.

9-1107

CHARACTERISTICS AND CRITICAL SKILLS	NOT RECOMMENDED FOR TESTING	RECOMMENDED FOR TESTING: ADEQUATELY TESTED BY USAF	RECOMMENDED FOR TESTING: NOT ADEQUATELY TESTED BY USAF
BIOGRAPHICAL DATA			
• LIFE INVENTORY			√
• ACADEMIC HISTORY		√	
• MILITARY HISTORY		√	
• MILITARY RANK		√	
RISK TAKING			
• WILLINGNESS TO TAKE CALCULATED RISKS			√
REACTIONS TO STRESS			
• PERFORMANCE UNDER STRESS			√
• EMOTIONAL CONTROL			√
• ABILITY TO WITHSTAND PSYCHOLOGICAL STRESS			√
• ANXIETY			√
SENSORY-MOTOR ABILITIES			
• VISUAL PERCEPTION			√
• MOTOR COORDINATION			√
• SPATIAL ORIENTATION			√
• SPATIAL-PERCEPTUAL ABILITY			√
• PERCEPTUAL SPEED			√
APTITUDE			
• PILOT COMPOSITES			√
• NON-PILOT COMPOSITES		√	
• GENERAL APTITUDE (INTELLIGENCE)		√	
• NUMERICAL SKILLS		√	
• VERBAL SKILLS		√	
• MECHANICAL SKILLS		√	
• FLIGHT APTITUDE			√
PERSONALITY			
• AGGRESSIVENESS			√
• SELF CONFIDENCE			√
• MENTAL HEALTH		√	
• CONSIDERATION FOR OTHERS	√		
• PERSONALITY STYLE			√
• COURAGE			√
PERSONALITY - LEADERSHIP			
• RESPONSIBILITY FOR MEN IN COMBAT			√
• PHYSICAL AND COMBAT LEADERSHIP			√
• ADMINISTRATIVE SKILLS	√		
• MILITARY BEARING	√		
SOCIAL FACTORS			
• TEAMWORK			√
• SOCIABILITY			√
• GROUP LOYALTY	√		
• INTERPERSONAL RATING			√
MOTIVATION			
• DETERMINATION/DESIRE			√
• SELF DISCIPLINE			√
• SATISFACTION			√
MEDICAL/PHYSIOLOGICAL			
• GOOD PHYSICAL HEALTH		√	
• ENDURANCE	√		
• PHYSICAL APTITUDE	√		
• ABILITY TO WITHSTAND PHYSIOLOGICAL STRESS			√
DECISION MAKING/INFORMATION PROCESSING			
• SELECTIVE ATTENTION			√
• DECISION TIME			√
• QUALITY OF COMBAT DECISIONS			√
• ALERTNESS			√
• INTEGRATIVE DECISIONS			√
AVIATOR SKILLS, KNOWLEDGES, AND TASKS			
• EQUIPMENT KNOWLEDGE			√
• FLIGHT SKILLS			√
• INSTRUMENT READING			√
• AERIAL GUNNERY			√

FIGURE 4.3-1 AN OVERVIEW OF CHARACTERISTICS AND CRITICAL SKILLS FOR THE PREDICTION OF THE COMBAT EFFECTIVE FIGHTER PILOT

5.0 DEVELOPMENT AND ANALYSIS OF THE PILOT LIFE INVENTORY QUESTIONNAIRE

A special paper-and-pencil selection device, the Pilot Life Inventory Questionnaire, is being developed. This potential selection device has been administered to most of the pilots who completed the Pilot Effectiveness Questionnaire discussed in Section 2. The present section focuses upon the development and preliminary validation efforts associated with the Pilot Life Inventory Questionnaire.

5.1 QUESTIONNAIRE RATIONALE

Paper-and-pencil testing has been an accepted component of most selection batteries for years. In many cases, tests devised for other purposes, such as determining personality or intelligence, have been used as part of a selection package. On the other hand, specially contrived tests have proven to be very useful for selecting individuals for highly specialized poisitions (Anastasi, 1976). There has been a scarcity of tests specially devised for selecting the combat effective. Our research has failed to identify a single test of combat effectiveness that has been adequately validated. Only one specially contrived test has been identified, and that one was developed over twenty years ago (Torrance, 1954).

As part of his study, Torrance (1954) contrasted the paper-and-pencil responses of a group of 27 Korean War aces and near aces with a matched group of 27 nonaces. A surprising difference in "efforts to obtain combat assignments" was found (see Figure 5.1-1A).[1] Even more dramatic differences were found when self-reported childhood aggressiveness was examined (see Figure 5.1-1B). These data reinforced our conviction that paper-and-pencil tests by themselves offer a potentially effective selection tool, albeit one whose principal power is limited primarily to certain personal factors.

To examine our hypothesis that these personal factors could be evaluated, and to determine the feasibility of using a paper-and-pencil test for revealing individual differences among fighter pilots, two goals were sought. First, we sought to demonstrate that we could develop an instrument sensitive to individual differences; and second, we sought to determine, in a preliminary manner, whether differences along specified criterion dimensions could be isolated. Both goals were accomplished.

9-1123

	27 ACES AND NEAR ACES	27 NONACES
DRIFTED INTO THE PROGRAM	2	17
MADE SOME SPECIAL EFFORT	9	5
MADE REPEATED SPECIAL EFFORTS	16	5

FIGURE 5.1-1A EFFORTS TO OBTAIN COMBAT ASSIGNMENT

	27 ACES OR NEAR ACES	27 MATCHED NONACES
NON-AGGRESSIVE FEW OR NO FIGHTS	0	8
USUAL AGGRESSIVENESS USUAL NUMBER FIGHTS	6	16
VERY AGGRESSIVE MANY FIGHTS	21	3

FIGURE 5.1-1B CHILDHOOD AGGRESSIVENESS

FIGURE 5.1-1 SAMPLE OF DISCRIMINATING QUESTIONNAIRE ITEMS (Torrance, 1954)

5.2 QUESTIONNAIRE DEVELOPMENT - PRELIMINARY FORM

A new instrument, the Pilot Life Inventory Questionnaire, was developed incorporating features of the Torrance (1954) test, but adapted to the aircraft and social milieu of the mid-1970s. To accomplish this, we turned to a general profile of the combat effective pilot. This profile was generated from a collection of approximately 100 personal

[1] It should be kept in mind that these data as well as those in Figure 5.1-1B were taken after the pilots had become aces.

factors which emerged from a preliminary literature review.[2] These personal factors were grouped into the 12 major categories shown in Figure 5.2-1.[3] We expected quantitative or qualitative differences between combat effective and combat ineffective pilots on these characteristics. The preliminary literature review and an evaluation of various standard tests confirmed the potential value of these categories and revealed "independence" as an additional personality characteristic to be evaluated. General personality testing has shown that these categories could be sampled, but sampling them for the specific purpose of selecting combat effective pilots is a relatively unexplored area, greatly limiting the sources of items for our questionnaire.

5.3 QUESTIONNAIRE ITEM DEVELOPMENT - PRELIMINARY FORM

We attempted to identify questions which would reveal the independence factor and the characteristics listed in Figure 5.2-1. In doing this, we placed more emphasis on, and developed more test items for, categories we felt could best be evaluated with paper-and-pencil tests. Although precedent exists for the categories selected, there was no predisposition to identify a predictive factor for each. Instead, these were stimuli for item development. Concepts such as personality and aggressiveness do not lend themselves to tight definition and, indeed, are fraught with added meaning. With this in mind, we were not particularly concerned with category overlap.

Test questions used by Torrance (1954) were classified according to the 13 categories (12 categories listed in Figure 5.2-1 plus the independence category). The item analysis of the life experience inventory provided by Torrance was reviewed as was his later report (Torrance, Rush, Kohn, and Doughty, 1957) which reported results of administering the inventory. In light of this information, the items from the life experience inventory were individually evaluated. If they appeared to have predictive value, they were updated for inclusion in the questionnaire. Rewriting ranged from slight modification in wording to the development of a completely new question based on the same theme.

The Edwards Personal Preference Schedule and other standardized personality tests (e.g., the Minnesota Multiphasic Personality Inventory) were also reviewed for test themes. These themes were the stimuli for questions, but in no case was an item from these tests used or modified as was done with items from the Torrance life experience inventory.

In addition, questions were developed to tap specific personality or interest areas which had been designated either by a panel of McDonnell Douglas Corporation fighter pilots or by our research personnel. These were sorted into the 13 categories. Figure 5.3-1 shows the category and general source of the majority of questions used (Questions 1-120).[4] The approach to each category is briefly outlined below.

General Intelligence - No attempt was made in this inventory to assess general intelligence, since military records include scores on conventional psychological tests of this class.

Physical Health - No attempt was made to assess physical health except for a single question in which the individual gives his own general impression of his health.[5] Physical health can be evaluated from conventional medical records.

Mental Health - As a general conclusion, the combat effective will be in a state of good mental health. Operating on the assumption that conventional pilot selection devices screen for mental

[2]Subsequently, we completed an extensive literature search. This literature is reviewed in Sections 3.2 through 3.4.and the resulting profile is presented in Section 4.0

[3]The development of the preliminary Pilot Life Inventory Questionnaire preceded the analysis of characteristics which appears in Section 4.0

[4]Twenty-one questions (Questions 121-141) were questions about famous fighter pilots.

[5]Combat ineffective personnel perceive themselves to be in poor physical health.

GENERAL INTELLIGENCE
- COMPREHENSION
- ABSTRACT REASONING
- QUICK LEARNING
- KNOWLEDGE
- AWARENESS MILITARY SITUATION
- ABILITY TO COMMUNICATE
- MECHANICAL COMPREHENSION
- MECHANICAL ABILITY

PHYSICAL HEALTH
- STAMINA
- VIGOR
- STURDINESS
- ENERGY
- FITNESS

MENTAL HEALTH
- MENTAL STABILITY
- EMOTIONAL ADJUSTMENT
- EMOTIONAL STABILITY
- EMOTIONAL MATURITY
- PSYCHOLOGICAL SOUNDNESS
- MANIFEST ANXIETY
- PSYCHOLOGICAL HEALTH
- EMOTIONAL CONTROL
- ADJUSTIVE SKILLS
- PEER ACCEPTANCE AND RESPECT
- SOCIAL ADJUSTMENT AND PARTICIPATION
- ADAPTABLE/FLEXIBLE

LIFE INVENTORY
- BIRTH ORDER
- AGE
- EARLY INDEPENDENCE TRAINING
- TESTING THE LIMITS OF BEHAVIOR (BREAKING THE RULES)
- EARLY PARENTAL CONTROL
- STABLE HOME LIFE WITH STRONG AFFECTIONAL TIES WITH PARENTS
- MORE FORMAL SCHOOLING
- PARENTAL STRIVING
- HIGHER SOCIOECONOMIC LEVEL
- POSITIVE FAMILY AFFECT

NEGATIVE CORRELATIONS
- CHILDHOOD NEUROTIC BEHAVIORS
- ILLNESS PATTERNS
- PSYCHIATRIC HISTORY
- DISCIPLINARY RECORDS

RISK TAKING BEHAVIOR
- RISK AND STRATEGY
- DESIRE FOR VARIED EXPERIENCE
- TAKING CALCULATED RISKS
- STIMULUS ADDITIVE – EXTEND TO PHYSICAL, EMOTIONAL OR INTELLECTUAL LIMITS
- WILLINGNESS TO TAKE CONSEQUENCES OF THEIR OWN BEHAVIOR
- LONERS
- FORTHRIGHTNESS
- RESOURCEFULNESS
- NONCONFORMITY
- REJECTION/NONCONFORMITY SOCIAL STANDARDS

PERSONALITY
- EGO STRENGTH
- STRONG SENSE REALITY
- WILL TO DOMINATE
- INTENSE INDIVIDUALITY
- DESIRE FOR SUCCESS/RECOGNITION
- ALERTNESS
- MASCULINITY
- DOER SYNDROME
- SELF-RESPECT
- SELF-ASSERTIVENESS
- SOCIAL RESPONSIBILITY
- CHEERFULNESS
- INGENUITY
- FORCEFULNESS
- COMMAND PRESENCE
- CAPACITY FOR TEAMWORK
- IN-GROUP-MINDEDNESS

GENERAL MOTIVATION
- DRIVE
- ZEAL FOR FLYING
- MOTIVATION FOR COMBAT
- STRIVING FOR SUCCESS
- DRIVE IN FACE OF HARDSHIP
- ACHIEVEMENT MOTIVATION

AGGRESSIVENESS
- PHYSICAL AGGRESSIVENESS
- PERSONAL AGGRESSIVENESS
- DISPLAYED AGGRESSIVENESS AND INITIATIVE

DETERMINATION
- INDIVIDUAL DETERMINATION
- PERSISTENCE
- SELF-DISCIPLINE
- IRON WILL

COURAGE
- PERSONAL COURAGE
- THE BRAVE HEART
- FEARLESS, BRAVE, GUTS

STRESS BEHAVIOR
- EFFICIENCY UNDER STRESS
- EMOTIONAL STABILITY UNDER STRESS
- TAKE CRISES IN STRIDE

LEADERSHIP
- CAPACITY FOR LEADERSHIP
- LEADERSHIP POTENTIAL
- LEADERSHIP SYNDROME
- LEADERSHIP OF STRUCTURED AND LEADERLESS GROUPS
- LEADERSHIP ABILITY AND PRACTICES

*THESE PERSONAL FACTORS WERE DERIVED FROM A PRELIMINARY LITERATURE REVIEW.

FIGURE 5.2-1 PRELIMINARY PROFILE OF PERSONAL FACTORS RELATED TO COMBAT EFFECTIVENESS*

9-1121

ITEM NO.	CATEGORY	SOURCE OF QUESTION THEME*				
		TORRANCE	EDWARDS	OTHER STANDARDIZED TESTS	PILOT PANEL	MDAC-EAST RESEARCH PERSONNEL
1	LEADERSHIP		X			
2	AGGRESSIVE-NESS		X			
3	LIFE INVEN-TORY	X				
4	DETERMINA-TION	X				
5	AGGRESSIVE-NESS					X
6	ACHIEVEMENT	X				
7	PERSONALITY		X			
8	MENTAL HEALTH	X				
9	ACHIEVEMENT			X		
10	PERSONALITY					X
11	AGGRESSIVE-NESS				X	
12	PERSONALITY					X
13	COURAGE					X
14	AGGRESSIVE-NESS			X		
15	INDEPENDENCE				X	
16	INDEPENDENCE					X
17	INDEPENDENCE				X	
18	LEADERSHIP		X			
19	LIFE INVEN-TORY					X
20	INDEPENDENCE			X		
21	INDEPENDENCE					X
22	INDEPENDENCE		X			
23	RISK TAKING				X	
24	AGGRESSIVE-NESS	X				
25	STRESS	X				
26	ACHIEVEMENT					X
27	COURAGE	X				
28	COURAGE				X	
29	DETERMINATION				X	
30	AGGRESSIVE-NESS	X				
31	AGGRESSIVE-NESS					X
32	PERSONALITY	X				
33	STRESS					X
34	PERSONALITY					X
35	AGGRESSIVE-NESS				X	
36	LEADERSHIP	X				
37	LEADERSHIP			X		
38	INDEPENDENCE	X				
39	PERSONALITY				X	

*GENERAL IDEAS WERE USED AS STIMULI FOR QUESTIONS, BUT NO ITEMS OR MODIFIED ITEMS FROM EXISTING TESTS WERE USED EXCEPT FOR SOME FROM THE TORRANCE LIFE EXPERIENCE INVENTORY.

FIGURE 5.3-1 TEST ITEM CATEGORIES AND SOURCES

9-1121-1

ITEM NO.	CATEGORY	SOURCE OF QUESTION THEME*				
		TORRANCE	EDWARDS	OTHER STANDARDIZED TESTS	PILOT PANEL	MDAC-EAST RESEARCH PERSONNEL
40	PERSONALITY					X
41	PERSONALITY			X		
42	PERSONALITY				X	
43	PERSONALITY		X			
44	ACHIEVEMENT					X
45	ACHIEVEMENT				X	
46	INDEPENDENCE	X				
47	INDEPENDENCE			X		
48	INDEPENDENCE	X				
49	INDEPENDENCE		X			
50	INDEPENDENCE					X
51	STRESS					X
52	RISK TAKING	X				
53	AGGRESSIVENESS	X				
54	AGGRESSIVENESS					X
55	PERSONALITY					X
56	LIFE INVENTORY	X				
57	RISK TAKING					X
58	RISK TAKING					X
59	INDEPENDENCE	X				
60	LEADERSHIP					X
61	ACHIEVEMENT					X
62	ACHIEVEMENT	X				
63	LEADERSHIP				X	
64	PERSONALITY					X
65	PERSONALITY				X	
66	PERSONALITY					X
67	ACHIEVEMENT	X				
68	ACHIEVEMENT					X
69	ACHIEVEMENT					X
70	COURAGE					X
71	DETERMINATION					X
72	STRESS				X	
73	LEADERSHIP		X			
74	AGGRESSIVENESS	X				
75	AGGRESSIVENESS					X
76	PERSONALITY					X
77	PERSONALITY					X
78	RISK TAKING					X
79	RISK TAKING				X	
80	LIFE INVENTORY	X				
81	COURAGE					X
82	AGGRESSIVENESS			X		

FIGURE 5.3-1 TEST ITEM CATEGORIES AND SOURCES (Continued)

health and eliminate those who are not of "good" mental health, only a few items were created for this category.

Life Inventory - Life inventory data have been useful in selecting out people who are a burden to the system. Torance, et al, (1957) noted that certain life inventory items showed high correlations

9-1121-2

ITEM NO.	CATEGORY	SOURCE OF QUESTION THEME*				
		TORRANCE	EDWARDS	OTHER STANDARDIZED TESTS	PILOT PANEL	MDAC-EAST RESEARCH PERSONNEL
83	LIFE INVENTORY	X				
84	LIFE INVENTORY	X				
85	PERSONALITY					X
86	RISK TAKING					X
87	INDEPENDENCE					X
88	ACHIEVEMENT	X				
89	RISK TAKING	X				
90	RISK TAKING					X
91	LIFE INVENTORY	X				
92	MENTAL HEALTH	X				
93	INDEPENDENCE	X				
94	INDEPENDENCE	X				
95	LIFE INVENTORY	X				
96	LIFE INVENTORY	X				
97	LIFE INVENTORY	X				
98	ACHIEVEMENT	X				
99	INDEPENDENCE	X				
100	AGGRESSIVENESS	X				
101	ACHIEVEMENT	X				
102	ACHIEVEMENT	X				
103	RISK TAKING	X				
104	STRESS	X				
105	DETERMINATION				X	
106	LIFE INVENTORY	X				
107	DETERMINATION	X				
108	DETERMINATION	X				
109	LIFE INVENTORY	X				
110	LIFE INVENTORY	X				
111	PHYSICAL HEALTH	X				
112	LIFE INVENTORY	X				
113	AGGRESSIVENESS	X				
114	MENTAL HEALTH	X				
115	LIFE INVENTORY	X				
116	AGGRESSIVENESS	X				
117	LIFE INVENTORY	X				
118	LIFE INVENTORY					X
119	ACHIEVEMENT	X				
120	AGGRESSIVENESS				X	

FIGURE 5.3-1 TEST ITEM CATEGORIES AND SOURCES (Continued)

with fighter pilot success. Because of this, some of the topics which were particularly useful for Torrance were expanded in the present test, and additional life inventory items were added. Life inventory information, in many cases, provides information for other categories. For example, aggressive behavior might occur more often in those who fought as children. This information on fighting as a child could legitimately be classed under personality or life inventory data. Generally, then, the life inventory class is restricted to biographical data, even though the life inventory approach might be used for other categories.

Risk Taking Behavior - All fighter pilots are risk takers by definition, but the items included in the risk taking category provide specifications of the degree of risk taking. Finer gradations of risk taking (particularly calculated risk taking) behavior were expected to have predictive value for our purposes.

Personality - A class of factors falling within what is generally considered the realm of personality was included. Personality is an intervening variable and, as such, cannot be directly assessed. Whether or not the label is appropriate for the factors involved is not critical. Of primary importance is whether or not the questions predict. With this in mind, the label "personality" is used.

Achievement (Motivation) - Like personality, motivation is not necessarily a good descriptor, but it may have predictive value. Aggressiveness and determination, factors which are generally thought to correlate with motivation, were included. One aspect of motivation, achievement, emerged from our literature review as important. Consequently, several questions exploring achievement were also used.

Aggressiveness - Not only is aggressiveness a common descriptor of combat effective individuals, but Torrance, et al, (1957) found it to be highly correlated with combat success. Knowing this, we developed numerous questions which evaluated this salient characteristic of the combat effective.

Determination and Courage - These common descriptors of combat effective individuals are probably best evaluated by methods other than paper-and-pencil tests. Because of this, only a few test items for these categories were included.

Stress Behavior - Reactions to stress are not readily evaluated by paper-and-pencil tests. Even

so, a few questions were included to assess the individual's subjective evaluation of his reactions in stressful situations. More useful data are expected to come from specially contrived situational tests, similar to those developed by the Office of Strategic Services (OSS Assessment Staff, 1948).

Leadership - Like some of the previously mentioned descriptors, leadership potential is more easily recognized in holistic testing.

Independence - Independence is likely to be revealed in various behaviors demonstrated by a youth. As such, some life inventory type questions directly addressing this topic were included. These cover reactions to authority and factors related to financial independence. Like aggressiveness, an independence factor was expected to emerge as a major predictor of combat effective fighter pilots.

The resultant version of the test was divided into two sections. Both include items generated to provide data on the various categories. Section one includes many items based principally on a Likert scale type of question relating to opposing adjectives, e.g., strongly agree - strongly disagree. Other items in section one require more specific answers, but, in all cases, a single response is required.

Section two includes questions with non-exclusive alternatives. Several answers are possible. This is particularly efficient for obtaining historical data when many life events may apply. The separation of sections one and two was done primarily with the logistics of test administration and scoring in mind. A simple answer sheet is used where practicable. Several items in section two might require so many responses as to unduly slow the test taker. Because of this, the answers go directly on the test paper even though this creates some additional work for the test scorer.

5.4 QUESTIONNAIRE DEVELOPMENT (SHORT FORM)

The preliminary version of the Pilot Life Inventory Questionnaire was administered to 13 pilot instructors and 26 student pilots at the Navy Fighter Weapons School at the Naval Air Station, Miramar, California. The instructors were highly experienced in teaching fighter tactics, and two of the 13 scored MIG kills in Southeast Asia. These instructor pilots are thought to be representative of the highly skilled and combat tempered fighter pilot, and, as such, they were used as a criterion group and contrasted with various student groups. The student pilots were themselves a highly select group in that they were all aircraft commanders. Therefore, finding differences among groups within this homogeneous population can be taken as prima facie evidence of the feasibility of distinguishing among fighter pilots.

An item analysis was performed on the responses of the instructors and students. The purpose of this analysis was to isolate those items which merited further study or refinement as predictors of fighter pilot performance. Our criteria for item selection were partly based upon phi correlation coefficients computed for each response alternative on each question.[6] Ten criteria were used. Four of these were variants of instructor versus student group membership, and six were student grades in Navy Fighter Weapons School. Further descriptions of these criteria and the computed phi coefficients may be found in Appendix 5.A.

The initial step in item selection was to retain those items having the highest coefficients. From item coefficients, it is possible to ascertain which items have predictive power and, with careful evaluation, which items can be modified to have greater predictive effectiveness. Caution was exercised, however, since some items could have high or low coefficients as a result of random variation. Tests of significance were made as an aid in making decisions about retaining items. The phi coefficient (ϕ) and chi square (χ^2) are

[6]The phi coefficient is a measure of the degree of relationship between two dichotomous variables.

closely related, and it can be shown that the critical values of ϕ for a test at the .05 and .01 levels are:

$$\phi_{.05} = \frac{1.96}{\sqrt{N}} \qquad \phi_{.01} = \frac{2.58}{\sqrt{N}}$$

where

N = the number of individuals in the upper criterion class plus the number in the lower criterion class.

For each of the pilot groupings and criterion measures used, a number of phi coefficients reached statistical significance. We reviewed the test item phi coefficients and selected for further analysis those items which yielded significant values. Because of the small sample of pilots per group, their homogeneity, and the preliminary nature of this questionnaire, it would have been premature to have relied too heavily on these statistics to select items for further study. We also retained items which, by inspection, showed promise of providing useful patterns of responses. Items similar to those found useful by Torrance, et al, (1957) were also selected for further study even when our preliminary evaluation yielded low phi values. These items were reviewed and collected into a revised "Pilot Life Inventory Questionnaire (Short Form)" (see Appendix 5.B).

5.5 PRELIMINARY VALIDATION OF THE PILOT LIFE INVENTORY QUESTIONNAIRE (SHORT FORM)

To properly validate a pilot selection device, one ideally would administer the device to a large sample of pilot candidates and track them for several years to see how responses to certain items correlate with demonstrated combat performance. This procedure defines predictive validation, i.e., prediction of future performance (Anastasi, 1968). Due to time and budgetary restraints, this procedure was not practicable. However, some indication of the predictive validity of a test instrument may be gained from a priori comparisons of potential criterion groups, i.e., concurrent validation (Anastasi, 1968). Therefore, we performed this type of validation procedure in a preliminary fashion. Section 5.5.1 describes the groups which have been sampled. Section 5.5.2 presents some a priori comparisons from selected items and a discussion of the data limitations in this preliminary validation effort.

5.5.1 Those Completing the Short Form

The 57 item short form was administered to seven groups of fighter pilots.

American Fighter Aces Association - This is an association of U.S. pilots who have shot down five or more enemy aircraft. Most of the membership attained ace status during either World War II or the Korean War. The respondents from this group include numerous notables, i.e., over two dozen generals and admirals. The responses of this group are of special interest because these men are aces. The importance attributed to these responses, while great, must be tempered by the knowledge that most of these men became aces over 25 years ago. The present researchers are acutely sensitive to the fact that reflections from the vantage point of maturity might predispose a man to respond differently than he would have responded when he was a new pilot. We are also aware of the substantial change in fighter planes over the past 35 years. Nevertheless, these American Fighter Aces Association members are the aces, and that makes their responses unique.

Navy MIG Killers Association - This is an association of Navy pilots and crewmen who achieved a MIG kill in Southeast Asia. Most of these men are still on flying status. They represent a more contemporary sample of men with proven combat capability.

Red River Valley Fighter Pilots Association (River Rats) - This is an organization of pilots who flew combat in the Red River Valley around the Hanoi region in North Vietnam. These combat experienced pilots are representative of the operational flying community.

Air Combat Evaluation (ACEVAL)-Air Intercept Missile Evaluation (AIMVAL) Pilots - This is a group of F-14 and F-15 crewmen who are currently

participating in a tactics and air intercept missile evaluation at the Air Force Air Combat Maneuvering Instrumentation (ACMI) facility at Nellis Air Force Base. These crews have been carefully and individually selected for this test program, and as such, they are considered to be among the best in their respective service. The Air Force and Navy ACEVAL-AIMVAL participants are treated separately and thus comprise two distinct groups.

Aggressor Squadron - The pilots in this unit are highly trained in enemy tactics and fly as the mock enemy for air combat training conducted at the ACMI at Nellis Air Force Base, Nevada. Like the ACEVAL-AIMVAL crews, these men are very carefully selected for this assignment.

National Guard Pilots - This group was included because a substantial number of cockpits are filled by Guardsmen and Reservists, and, as such, these groups should be sampled. Pilots from the Air National Guard unit at Lambert Field, St. Louis, Missouri, were sampled.

The groups, number of questionnaires distributed, and number of questionnaires returned are shown in Figure 5.5-1.[7]

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PILOT ORGANIZATION	NUMBER DISTRIBUTED	NUMBER RETURNED	PERCENT RETURNED
AMERICAN FIGHTER ACES ASSOCIATION	524	257	49
NAVY MIG KILLERS ASSOCIATION	42	22	52
RED RIVER VALLEY FIGHTER PILOTS ASSOCIATION (RIVER RATS)	99	51	51
NATIONAL GUARD PILOTS	40	13	33
ACEVAL-AIMVAL NAVY PILOTS	12	12	100
ACEVAL-AIMVAL AIR FORCE PILOTS	6	6	100
AGGRESSOR SQUADRON AT NELLIS	12	12	100
TOTAL	735	373	51

FIGURE 5.5-1 SUMMARY OF RESPONSE FREQUENCIES TO THE PILOT LIFE INVENTORY QUESTIONNAIRE (SHORT FORM)

5.5.2 Preliminary Comparisons and Data Analysis - In examining the concurrent validity of the short form of the Pilot Life Inventory Questionnaire, one potentially useful comparison is to contrast the combined responses of the Navy MIG Killers, the Air Force and Navy ACEVAL-AIMVAL pilots, and the members of the Aggressor Squadron, with those of the River Rats (Comparison 1). This constitutes a comparison of groups ordered along a criterion dimension of fighter pilot ability.[8]

A comparison of the responses of the members of the American Fighter Aces Association with those of the River Rats (Comparison 2) is interesting but confounded with age and the accompanying societal differences. If it were not for this issue, this comparison would contrast aces with nonaces. Nevertheless, it can still be a valuable comparison. As an aid to the interpretation of any differences which might be obtained in this comparison, it would be useful to contrast the best fighter pilots from each era. Such a comparison results when the responses of the members of the American Fighter Aces Association are contrasted with those of the ACEVAL-AIMVAL crews, the members of the Aggressor Squadron, and the Navy MIG Killers combined (Comparison 3).

The groups being compared in this sample comprise a single, rather homogeneous sample. They are alike in that, in all cases, these men have flown in an operational setting; and by the time fighter pilots are in the operational environment, they have survived several formal and informal screenings. It is, of course, more difficult to get differences between subsets of a homogeneous group than between more disparate groups. This homogeneity imposes a limitation on our analysis.

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[7]The Short Form has also been distributed to Air Force MIG Killers and a matched sample of Air Force pilots. The responses of those samples will be analyzed separately and reported elsewhere.

[8]We in no way mean to imply that the membership of the Red River Valley Fighter Pilots (River Rats) is not a highly competent group of pilots. Clearly, these combat seasoned men are the backbone of the current fighter pilot community. These men, as a group, have not, however, undergone the same review as have the Navy MIG Killers, the ACEVAL-AIMVAL pilots, or the Aggressor Squadron Pilots.

Our first attempt at direct comparisons involved the computation of the statistic phi for each item for each of the comparisons. For this first attempt, excluding a handful of clearly nominal scale items, only one of several possible response distribution breakpoints was used. For example, if the response alternative were strongly agree, agree, no opinion, disagree, and strongly disagree, the responses in most cases were dichotomized into strongly agree and agree versus the other three alternatives. Of course, it is possible that dividing the distribution between strongly disagree and all other alternatives might have yielded clearer results.

One method which can be employed to determine distribution break points without introducing ex post facto bias is to divide the frequency distribution of responses for each item as close as possible to the median. Phi coefficients using such breakpoints were not computed. Instead, phi coefficients were computed with the distribution divided according to a priori reasons. An example of the difference in results which can be obtained with the two procedures is shown for item 17 in a comparison of the River Rats with the combined group of Navy MIG Killers, ACEVAL-AIMVAL pilots and Aggressor pilots. Item 17 is, "It bothers me to lose a game,

1. Very much
2. Somewhat
3. Very little
4. Not at all."

Our first attempt at analyzing this item called for a break between response two and response three. Dividing the distribution that way resulted in a phi value of 0.146. Breaking near the median divided the group between responses one and two and resulted in a phi of 0.199 which exceeded 0.193, the critical value for significance at the .05 level. Of course, some breakpoints would not change, and some changes in the breakpoint could result in diminishing values of phi. Either way, until the more complete analysis is performed, the phi values discussed here are considered preliminary. Because of this, only a few selected items are discussed in detail. A more thorough analysis has been proposed as part of a continuation effort.

Question 28, which inquired about the type of work the pilots' fathers performed, is illustrative of a basic biographical information question. The comparison of the River Rats with the combination of Navy MIG Killers, ACEVAL-AIMVAL pilots, and the Aggressor pilots showed that of the River Rats sampled, 15% had fathers who were professionals; whereas in the combined group, 38% of the fathers were professionals. The associated phi value was sufficiently high to be considered significant [$\phi(103) = .234$, $p < .05$]. A related finding is that a greater percentage of the River Rats' fathers were semiskilled workers than in the combined group or the group of American Fighter Aces. The validity coefficients for both comparisons were significant [$\phi(103) = .251$, $p < .05$ and $\phi(294) = .151$, $p < .05$, respectively].

A behavioral feature cited by Torrance, et al, (1957) as characteristic of superior fighter pilots was their motivation to get into the fighter program. Question 47 directly addressed this issue, and the preliminary results are consistent with those of Torrance, et al. Question 47 reads, "If blocked from pilot training for minor physical reasons, such as 20/25 vision, color vision weakness, height or weight, I would: (Check as many as apply)

1. Accept the decision
2. Try to correct the defect in an acceptable fashion
3. Memorize the eye chart or otherwise fudge the results
4. Seek a waiver
5. Use influence to get an exception made."

The responses of the River Rats differed from those of the combined group of Navy MIG Killers, Aggressor pilots, and ACEVAL-AIMVAL pilots. Twenty-two percent of the River Rats indicated that they would try to use influence, whereas 40% of the combined group of pilots indicated that they would seek a waiver. The validity coefficient for this

response alternative was statistically significant [$\phi(103) = .205$, $p < .05$]. Unlike the Torrance, et al, (1957) findings, the other response alternatives were chosen almost equally frequently by these groups.

A difference between the American Fighter Aces and both contemporary pilot groups was the difference in the frequency of response to alternative one of Item 47. A few (14%) of the American Fighter Aces indicated that they would abide by the decision. Hardly any of the contemporary sample answered response one (2%). This difference is likely to be due to cultural differences from the 1940s and 1950s to the present.

The responses to Question 40 also provided information relevant to the hypothesis considered by Torrance, et al, (1957). Torrance, et al, (1957) posited that superior fighter pilots had more childhood fights. Question 40 is, "In fights that you have been in, were your opponents:

1. From the same neighborhood
2. From across town
3. From another town
4. This does not apply since I never fought."

Twenty percent of the River Rats, a random sample of combat experienced pilots, indicated response 4, whereas only four percent of the group of highly selected pilots (ACEVAL-AIMVAL pilots, Aggressor pilots, and Navy MIG Killers) chose response 4 [$\phi(103) = .215$, $p < .05$]. This suggests that almost all of our sample of contemporary pilots classed as superior fighter pilots have shown aggressiveness as evidenced in fighting.

As noted earlier, without further statistical analysis, only suggestive comments can be made with regard to differential responding by the various pilot groups. The following emerge from our test development activities as reasonable hypotheses. Pilots with demonstrated combat effectiveness tend to:

- Be frank. They will tell others what they think
- Be more aggressive as evidenced by fighting behavior
- Be leaders in that in group settings others tend to go along with their stated positions
- Want to do things their way. They do not like losing games and do not participate in activities for the sake of participation
- Be well adjusted as reflected in the ability as children, to change schools easily
- Be from upper middle class social and educational backgrounds.

5.6 SUMMARY

A paper-and-pencil selection device, the Pilot Life Inventory Questionnaire (Short Form), has been developed. Items for this questionnaire were devised to sample personal factors in 13 domains (life inventory, risk-taking, intelligence, physical health, mental health, personality, motivation, aggressiveness, determination, courage, stress reactions, leadership, and independence).

The questionnaire was administered to volunteers from seven pilot groups (American Fighter Aces Association, Navy MIG Killers Association, Red River Valley Fighter Pilots Association, Navy and Air Force ACEVAL-AIMVAL[9] programs, Air National Guard (in St. Louis, Missouri) and the Aggressor Squadron at Nellis Air Force Base). The data collected from these pilots were analyzed in a preliminary fashion. Interim conclusions tend to support the position that effective fighter pilots are aggressive, frank, well adjusted, and leaders. Additional information about fighter pilots is likely to emerge from further multivariate analyses of the data.

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[9]Documentation used in preparing this report referred to this program as ACEVAL-AIMVAL. For consistency, this acronym is used throughout the report, although the current appelation of the program is AIMVAL-ACEVAL.

6.0 EVALUATION OF SIMULATORS AND INSTRUMENTED AIR COMBAT MANEUVERING RANGES FOR THE SELECTION OF COMBAT EFFECTIVE PILOTS

This section reviews selected air combat simulators and instrumented air combat ranges to evaluate their potential as selection test beds for the prediction of combat effectiveness. This analysis delineates the characteristics of the existing facilities, identifies the type of use to which they have been put, and describes the parameters analyzed and the pilot proficiency measures used to evaluate the results. Where adequate data are available, the reliability and validity of the performance measures were analyzed to determine whether the data generated discriminated between pilots. Where possible, performance in the facilities was checked against some independent measure of flying capability. A brief summary of the findings of this section is presented in Figure 6.0-1.

6.1 AIR COMBAT MANEUVERING SIMULATORS

Since 1968 a number of major air combat maneuvering simulators have been constructed by NASA, the military, and the aerospace industry. Sparked by the availability of large capacity computers and advances in electronics technology, these simulators have been designed to include a real-time, full mission capability including, in some cases, the air-to-air combat mission. Their primary purposes have been for pilot training and aircraft design, as well as for tactics, weapons systems, and avionics evaluation. For the first time, it was possible to evaluate the capability of new aircraft concepts with a pilot-in-the-loop system. This section investigates the possibility that the new generation of man-in-the-loop air combat simulators can be used as a tool to evaluate the air-to-air combat capabilities of pilots. Should this prove true, air combat simulation offers a new approach and potentially powerful tool for selecting combat effective pilots.

This section reviews four major simulation facilities having an interactive air-to-air combat capability. These include: the McDonnell Douglas Manned Air Combat Simulator (MACS) at St. Louis, Missouri; the Differential Maneuvering Simulator (DMS) at NASA, Langley, Virginia; the Simulator for Air-to-Air Combat (SAAC) at Luke AFB, Arizona; and the Advanced Simulator for Undergraduate Pilot Training (ASUPT) at Williams AFB, Arizona. The MACS, DMS, SAAC and ASUPT are the best combat simulators presently available. Multiple visits were made to each of these facilities to gather information on (1) their capabilities, (2) the way in which they have been used, and (3) data generated from air-to-air combat which could be used to evaluate their utility as a tool for pilot selection.

Our review found that the MACS and the DMS were capable of high fidelity air-to-air combat simulations. Both the SAAC and the ASUPT, which were designed for training purposes, would require improvements in the out-of-the window display, and the ASUPT would require significant modifications for inclusion of a weapons system.[1] These systems did, of course, show utility as training devices.

A number of problems were identified in utilizing simulators as selection tools. Among these are the problem of getting adequate performance measures, what these measures should be (kills, time in envelop, or what?) and a general lack of consistency in performance measures between simulations. A number of measurement and operational innovations were noted which offer the possibility of solutions to some of these problems. Among these are the Adaptive Maneuvering Logic (AML) model developed by NASA, Langley, which provides a consistent, computer-generated opponent against which pilots can be evaluated, and the AML scoring system which appears to provide a reliable measure of pilot proficiency which correlates well with the ultimate criterion - kills. Overall, it appears

[1]The CRT system does not allow adequate definition of the opponent aircraft at long range. This eliminates many of the key cues used in "anticipating" an opponent's maneuvers which are fundamental to executing effective offensive or defensive countermaneuvers.

SIMULATORS	FACILITY DESCRIPTION	TYPE OF STUDY	PARAMETERS STUDIED	PERFORMANC
MANNED AIR COMBAT SIMULATOR (MACS) MCDONNELL DOUGLAS, ST. LOUIS, MO.	STATE-OF-THE-ART 1968–1972 WITH ON LINE COMPUTER INTERACTIVE FLIGHT CAPABILITY ALLOWING ONE-ON-ONE TO THREE-ON-ONE COMBAT SIMULATIONS. SIMULATIONS LIMITED ONLY BY AVAILABLE SOFTWARE PROGRAMS. CAN USE ACTIVE TWO MAN COCKPITS. FOUR PILOT STATIONS – TWO WITH 20 FT VIRTUAL IMAGE SCREEN – TWO WITH 40 FT PROJECTED IMAGE SCREENS. ACTIVE HUD, INSTRUMENTS, SOUND AND "G" CUES. ON LINE WEAPONS EVALUATION	AIRCRAFT AND COCKPIT DESIGN EVALUATION OF AIR-TO-AIR CAPABILITY OF EXISTING AND ADVANCED DESIGN AIRCRAFT CONCEPTS TRAINING FOR F–15, AV–8A F–18 AIRCRAFT DURING PREFLIGHT TESTING	• WING LOADING • AIRCRAFT CONFIGURATION • CONTROL CHARACTERISTICS • HI-"G" COCKPIT • NEW WEAPONS CONCEPTS • TACTICS DEVELOPMENT	• TIME IN GUN EN • WEAPON HITS • THEORETICAL • GUN FIRING TI • ROUNDS FIRED • KILL PROBABIL • AIRCRAFT PAR (SPEED ALTITU
DIFFERENTIAL MANEUVERING SIMULATOR (DMS) NASA, LANGLEY, VA.	STATE-OF-THE-ART 1968 WITH RECENT UPDATES TO INCLUDE NEW HUD, CONTROL COMMAND SYSTEM AND ON LINE WEAPONS EVALUATION. CONSISTS OF TWO 40 FT PROJECTION DOMES WITH ON LINE INTERACTIVE COMPUTER CONTROL ONE-ON-ONE MISSIONS. HAVE DEVELOPED COMPUTERIZED MODEL FOR COMBAT FLYING WHICH CAN REPLACE PILOT IN ONE SPHERE. MODEL FUNCTIONS AS COMPETITIVE OPPONENT FOR LIVE PILOTS	AIRCRAFT EVALUATION OF DESIGN OPTIONS FOR AFTI, HIMAT, AV–8A F–4. PARAMETRIC STUDIES OF A NUMBER OF DESIGN OPTIONS. EVALUATION OF TRAINING METHODS	• WING LOADING • AIRCRAFT CONFIGURATION • THRUST VECTORING • MANEUVERING AUGMENTATION • ADAPTIVE MANEUVERING LOGIC MODEL • THRUST TO WEIGHT STUDIES	• TIME ON OFFE • TIME ON OFFE VANTAGE • AMLS, GUN HITS • AIRCRAFT PAR • TIMES IN VARIO ENVELOPES
ADVANCED SIMULATOR FOR UNDERGRADUATE PILOT TRAINING (ASUPT) WILLIAMS, AFB, AZ.	BECAME OPERATIONAL 1975. CONSISTS OF TWO T–37B COCKPITS AND WAS DESIGNED AS A TRAINING AND RESEARCH TOOL. SYSTEM IS NOT SET UP FOR AIR-TO-AIR COMBAT BUT COULD BE MODIFIED TO INCLUDE THAT CAPABILITY. THE ASUPT HAS A SIX DEGREE OF FREEDOM MOTION CAPABILITY AND USES CRT TECHNOLOGY FOR THE OUT OF THE COCKPIT DISPLAYS. UTILIZATION HAS EMPHASIZED TRAINING RESEARCH	TRANSFER OF TRAINING VALUE OF SIMULATOR MOTION VISUAL PARAMETERS REQUIRED IN TRAINING (TRAFFIC PATTERNS; CONTACT FLYING; INSTRUMENT FLYING) DEFINITION OF SIMULATOR REQUIREMENTS	• A/G TRAINING AS A FUNCTION OF SIMULATOR MOTION • SIMULATOR REQUIREMENTS FOR WIND, TURBULENCE, "G" SEAT AND FIELD OF VIEW	• BOMBING CEP • AIRCRAFT CON STEADINESS) • MEASURES OF A FLIGHT DEVIAT TAKEOFF, CL 360° OVERHEAD LANDING
SIMULATOR FOR AIR-TO-AIR COMBAT (SAAC) LUKE, AFB, AZ.	DELIVERED IN 1975, THIS SYSTEM CONSISTS OF TWO F–4 FORWARD COCKPITS, A SIX DEGREE OF FREEDOM MOTION CAPABILITY, CRT OUT-OF-THE-COCKPIT SCENE GENERATION AND "G" CUES. IT IS LIMITED TO SIMULATION OF AIR-TO-AIR SEGMENTS OF THE FLIGHT REGIME. THIS SYSTEM IS PRIMARILY A TRAINING TOOL FOR AIR COMBAT AND TACTICS ALTHOUGH IT HAS BEEN USED AS A MEANS FOR EVALUATING DESIGNS AND MAKING DISSIMILAR AIRCRAFT COMPARISONS	TRAINING EFFECTIVENESS OF THE SIMULATOR (TAC ACES II). PRIMARILY AN AIR-TO-AIR SIMULATOR USED FOR TRAINING IN THE TACTICAL AIR COMMAND	TRAINING EFFECTIVENESS OF SYSTEM. THEY HAVE USED A SERIES OF THREE MANEUVERS TO EVALUATE PILOT CAPABILITY	• MISSILE LAUNC • GUN ROUNDS FI • MISSILE AND GU • KILLS • TIME TO KILL
INSTRUMENTED RANGES				
AIR COMBAT MANEUVERING RANGE (ACMR) MARINE CORPS AIR STATION, YUMA, AZ.	THIS SYSTEM BECAME OPERATIONAL IN 1973 AND CAN TRACK, THROUGH A SERIES OF REMOTE TRACKING STATIONS, UP TO FOUR HIGH SPEED AIRCRAFT WITHIN A 30 MILE CYLINDER AT ALTITUDES OF FROM 5 TO 40 THOUSAND FEET. DATA ON TRACKING, WEAPONS SELECTION, RADAR LOCK-ON, AND AIRCRAFT ATTITUDE, ALTITUDE, ACCELERATION, ANGLE OF ATTACK AND AIRSPEED ARE DATA LINKED TO A GROUND STATION AND RECORDED. EXTENSIVE DEBRIEFING FACILITIES ARE PART OF THE SYSTEM TO ALLOW REVIEW OF THE MISSIONS FLOWN ON THE RANGE. AN ADDITIONAL RANGE HAS BEEN CONSTRUCTED IN VIRGINIA	TRAINING TO HELP NEW PILOTS DEFINE THE MISSILE ENVELOPE CANNOT USE GUNS WITH CURRENT SYSTEM. EVALUATION OF NEW AIRCRAFT SYSTEMS IN MOCK COMBAT ENGAGEMENTS. ACCEPTANCE TESTING OF NEW FIGHTER AIRCRAFT	• N VS N AIRCRAFT TACTICS • AIR GROUND COORDINATION • DISSIMILAR AIRCRAFT TACTICS	• TIME IN ENVEL • MISSILE LAUNC • MISSILE HITS • INSTRUCTORS' • AIRCRAFT PAR • DEVELOPING A COMPOSITE SC FORMANCE IND
AIR COMBAT MANEUVERING INSTRUMENTATION (ACMI) NELLIS, AFB, LAS VEGAS, NEV.	THIS SYSTEM IS ESSENTIALLY AN ADVANCED ACMR. IT BECAME OPERATIONAL IN JULY 1976 AND CAN TRACK UP TO EIGHT AIRCRAFT. EXPANDED DEBRIEFING FACILITIES HAVE BEEN PROVIDED INCLUDING A LARGE SCREEN COLOR DISPLAY. INCREASED MISSILE TRACKING, MISSILE KILL PROBABILITY DATA AND GUN FIRING DATA ARE ALSO INCLUDED IN THE NEW SYSTEM. ANOTHER SIMILAR RANGE IS BEING CONSTRUCTED AT TYNDAL AFB IN FLORIDA	EVALUATION OF NEW MISSILE SYSTEM TACTICS – CURRENTLY USED FOR ACEVAL-AIMVAL PROGRAM; A JOINT AIR FORCE NAVY (F-14, F–15) WEAPONS AND TACTICS EVALUATION PROGRAM	• N VS N AIRCRAFT TACTICS • AIR GROUND COORDINATION • DISSIMILAR AIRCRAFT TACTICS • MISSILE CONCEPT EVALUATION	• SAME AS ACMR • INCLUDES GUN PROBABILISTIC BULLET DISPE THE CONE OF ERROR OF THE • THEORETICAL (HIT IF FIRED)

FIGURE 6.0-1 OVERVIEW OF FACILITIES STUDIED AND RESULTS OF THE EVALUATION OF MANEUVERING RANGES AS SELECTION TOOLS

DOUGLAS CORPORATION

PARAMETERS STUDIED	PERFORMANCE MEASURES	RELIABILITY	VALIDITY	RELATION TO COMBAT
• WING LOADING • AIRCRAFT CONFIGURATION • CONTROL CHARACTERISTICS • HI-"G" COCKPIT • NEW WEAPONS CONCEPTS • TACTICS DEVELOPMENT	• TIME IN GUN ENVELOPE • WEAPON HITS • THEORETICAL WEAPONS HITS • GUN FIRING TIME • ROUNDS FIRED • KILL PROBABILITY • AIRCRAFT PARAMETERS (SPEED ALTITUDE, "Gs", ETC)	• GOOD MECHANICAL RELIABILITY • SMALL SAMPLE SIZE DID NOT ALLOW ADEQUATE SAMPLE TO PERFORM MEANINGFUL STATISTICS REGARDING INDIVIDUAL RELIABILITY • DATA TENDED TO GROUP GOOD AND POOR PILOTS ACROSS ALL MEASURES	• COMPARISONS WERE MADE BETWEEN AIR COMBAT MANEUVERING IN THE SIMULATOR AND IN FLIGHT TEST. GOOD CORRESPONDENCE BETWEEN SIMULATOR AND STREAK EAGLE RECORD TIME-TO-CLIMB TESTS	NO DATA
• WING LOADING • AIRCRAFT CONFIGURATION • THRUST VECTORING • MANEUVERING AUGMENTATION • ADAPTIVE MANEUVERING LOGIC MODEL • THRUST TO WEIGHT STUDIES	• TIME ON OFFENSE • TIME ON OFFENSE WITH ADVANTAGE • AMLS, GUN HITS, MISSILE HITS • AIRCRAFT PARAMETERS • TIMES IN VARIOUS OFFENSIVE ENVELOPES	• GOOD MECHANICAL RELIABILITY • INDIVIDUAL RELIABILITY FOR KILLS AND AMLS MEASURES GOOD (0.78 AND 0.82, RESPECTIVELY) TIME ON OFFENSE RELIABILITY POOR (0.27) • INDICATES GOOD MEASURE OF INDIVIDUAL PERFORMANCE CAN BE OBTAINED WITH A SIMULATOR	GOOD COMPARISONS WERE FOUND BETWEEN FLIGHT TEST AND SIMULATOR FOR AERODYNAMIC QUALITIES. ALSO GOOD DATA WITH RESPECT TO TRACKING RUNS. RESULTS ON AIR-TO-AIR MANEUVERING WERE ALSO GOOD WHEN COMPARED WITH RESULTS OF COMBAT HASSLE PROGRAM	NO DATA
• A/G TRAINING AS A FUNCTION OF SIMULATOR MOTION • SIMULATOR REQUIREMENTS FOR WIND, TURBULENCE, "G" SEAT AND FIELD OF VIEW	• BOMBING CEP • AIRCRAFT CONTROL (STICK STEADINESS) • MEASURES OF AIRCRAFT FLIGHT DEVIATIONS DURING TAKEOFF, CLIMB ON COURSE 360° OVERHEAD PATTERN, AND LANDING	• MECHANICAL RELIABILITY GOOD • NO DATA ON RELIABILITY OF INDIVIDUAL MEASUREMENT	NO DIRECT FLIGHT TEST COMPARISONS. CAREFUL "FEEL" EVALUATION BY GROUP OF PILOTS. GENERALLY OK EXCEPT FOR SOME DEFECTS IN THE CONTROL LATENCY AND THE VISUAL SYSTEM	NO DATA
TRAINING EFFECTIVENESS OF SYSTEM. THEY HAVE USED A SERIES OF THREE MANEUVERS TO EVALUATE PILOT CAPABILITY	• MISSILE LAUNCHES • GUN ROUNDS FIRED • MISSILE AND GUN HITS • KILLS • TIME TO KILL	• INDICATIONS THAT MECHANICAL RELIABILITY NEEDS UPGRADING • NO DATA ON RELIABILITY OF INDIVIDUAL MEASUREMENT	LIMITED TO THE RESULTS OF THE FOLLOW-ON TEST AND EVALUATION OF THE SIMULATOR JUNE 1976. PILOT OPINION INDICATED IT COULD BE USED TO TRAIN SELECTED ASPECTS OF FLIGHT BUT IT ALSO NEEDED IMPROVEMENT IN SOME OF THE AREAS	NO DATA
• N VS N AIRCRAFT TACTICS • AIR GROUND COORDINATION • DISSIMILAR AIRCRAFT TACTICS	• TIME IN ENVELOPE • MISSILE LAUNCHES • MISSILE HITS • INSTRUCTORS' JUDGEMENTS • AIRCRAFT PARAMETERS • DEVELOPING A CONTINUOUS COMPOSITE SCORING PERFORMANCE INDEX	• MECHANICAL RELIABILITY GOOD; MEETS SPECS ON ACCURACY • NO DATA ON RELIABILITY WITH RESPECT TO INDIVIDUAL PERFORMANCE. SUCH RECORDS NOT AVAILABLE TO US	PILOT OPINION REGARDS RANGE AS USEFUL TRAINING TOOL. LARGEST SINGLE DRAWBACK IS NO REAL BULLETS – FEAR IS NOT A FACTOR. HOWEVER, THE MAJORITY OF PILOTS BELIEVE PERFORMANCE ON RANGE SHOULD MIRROR PERFORMANCE IN COMBAT	RESULTS OF TOP GUN SCHOOL INDICATED SIGNIFICANT OVERALL IMPROVEMENT IN KILL/LOSS RATIOS IN VIETNAM FOR TOP GUN GRADUATES BUT DATA ARE CONFOUNDED BY SELECTION PROCEDURES FOR TOP GUN
• N VS N AIRCRAFT TACTICS • AIR GROUND COORDINATION • DISSIMILAR AIRCRAFT TACTICS • MISSILE CONCEPT EVALUATION	• SAME AS ACMR • INCLUDES GUN HITS BASED ON PROBABILISTIC MEASURES OF BULLET DISPERSION WITHIN THE CONE OF MEASUREMENT ERROR OF THE SYSTEM • THEORETICAL MISSILE HITS (HIT IF FIRED)	SAME AS ACMR POSSIBILITY OF DATA ON ACEVAL-AIMVAL PILOTS DURING CURRENT PROGRAM. SHOULD BE DONE TO EVALUATE INDIVIDUAL RELIABILITY	NO DATA OPERATION TOO RECENT TO HAVE GENERATED SIGNIFICANT DATA	NO DATA

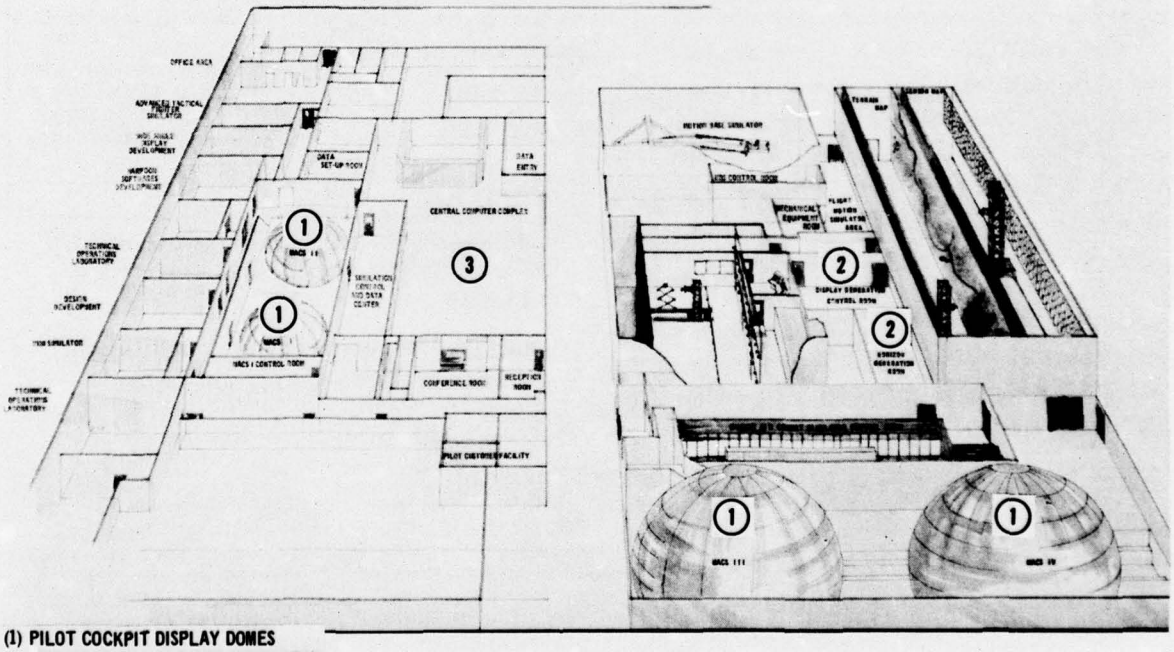
AND RESULTS OF THE EVALUATION OF SIMULATORS AND AIR COMBAT

that simulators can be specially designed so as to provide adequate test beds for pilot selection purposes and further, that data produced from man-on-man air combat simulation encounters can be used to reliably discriminate among pilots.

6.1.1 The McDonnell Douglas Manned Air Combat Simulator at St. Louis, Missouri - The McDonnell Douglas Manned Air Combat Simulator (MACS) system has been in continuous operation since 1969. During that time, heavy emphasis has been placed on air-to-air combat simulations as they relate to advanced engineering and avionics evaluations. Over the years the hardware/software that drive the MACS have been improved several times so that today MACS represents a reliable air-to-air combat simulation test bed (see Figure 6.1-1).

6.1.1.1 Facilities Description - The MACS is a real-time, fixed base, four aircraft simulator employing four piloted crew stations, all with out-the-window visual scenes. These crew stations are "linked together" through computers to provide an interactive air-to-air simulation of one-versus-one up to a two-versus-two combat engagement scenario. All cockpits are especially configured to represent the particular

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(1) PILOT COCKPIT DISPLAY DOMES
(2) AIRCRAFT AND HORIZON GENERATOR
(3) COMPUTER CONTROL

FIGURE 6.1-1 THE MCDONNELL DOUGLAS FLIGHT SIMULATION FACILITY
THE MCDONNELL DOUGLAS MANNED AIR COMBAT SIMULATOR (MACS) IS EMBEDDED IN THE LARGER FLIGHT SIMULATION FACILITY AT ST. LOUIS, MISSOURI.
THE PRINCIPAL COMPONENTS OF THE MACS ARE SHOWN ABOVE.

simulated aircraft and employ active flight instrumentation including a three-axis attitude direction indicator, a Mach meter, an airspeed indicator, an angle-of-attack indicator, a rate of climb indicator, an altimeter and a g meter.[2]

The 35 air-to-air combat simulation studies (totaling more than 6,000 engagements) conducted in MACS have evaluated F-4, F-15, F-18, AV-8A fighter aircraft, as well as a number of advanced design aircraft concepts. Threat aircraft have included the MIG-17, the MIG-23 and USAF aircraft such as the F-4, F-5, and F-106. All 35 simulation studies were reviewed to identify those having sufficient commonality and experimental goodness for purposes of this evaluation. A summary of these simulations is shown in Figure 6.1-2A

Because of the differences in aircraft and weapons systems studies, some criteria for commonality were required to get comparable measures of effect between simulation studies. To accomplish this, and to maintain the largest number of simulations possible, a guns-only, one-on-one scenario was chosen. This is the only specific commonality between the simulations evaluated. The guns-only scenario involves concentrated maneuvering and a final close in - 3000 feet or less - approach to the adversary aircraft, two factors which are well suited to evaluating pilot proficiency. This criterion eliminated 25 of the 35 studies listed in Figure 6.1-2A.[3] A number of procedural criteria were used to evaluate the remaining ten studies.

First, a minimum of three pilots must have participated in the study. Second, each pilot must have flown at least 25 sorties to establish a reasonable data base. Third, the study itself must have been conducted in a relatively orderly fashion with a minimum of engineering changes in procedures, hardware and software during the course of the study. This eliminated three more studies leaving a total of seven studies which met our minimal criteria. These studies comprised a total of over 1500 sorties and 30 pilots, approximately a fourth of the total number of sorties run over the last five years (see Figure 6.1-2B). The studies dealt

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AIRCRAFT	NUMBER OF SIMULATIONS	NUMBER OF ENGAGEMENTS	PURPOSE OF SIMULATION
F-15	13	2097	FLIGHT TEST TRAINING, ONE-ON-ONE, TWO-ON-ONE, BEYOND VISUAL RANGE MISSILES, ENGINEERING EVALUATIONS
AV-8A	7	1250	PROCEDURAL EVALUATION OF NOZZLE CHANGES, TWO-ON-ONE, AV-8A VERSUS MIG-17 AND MIG-21.
F-4	3	516	BEYOND VISUAL RANGE MISSILE.
ADVANCED AIRCRAFT	12	2203	WEAPONS EVALUATION, EVALUATION OF AVIONICS AND AIRCRAFT DESIGN CONCEPTS.
TOTAL	35	6066	

FIGURE 6.1-2A MACS SIMULATIONS REVIEWED TO DEVELOP DATA BASE FOR EVALUATION OF SIMULATORS AS A SELECTION TOOL

9 – 1050

AIRCRAFT	NUMBER OF SIMULATIONS	NUMBER OF ENGAGEMENTS	PURPOSE OF SIMULATION
F-15	1	192	F-15 VERSUS MIG-23
AV-8A	3	888	AV-8A VERSUS MIG-17 AND MIG-21
ADVANCED AIRCRAFT	3	435	HIGH ACCELERATION COCKPIT, ADVANCED TACTICAL FIGHTER, VERTICAL LIFT FIGHTER AIR COMBAT PERFORMANCE EVALUATION
TOTAL	7	1515	

FIGURE 6.1-2B MACS SIMULATIONS WHICH MET THE CRITERIA FOR USE AS SIMULATOR EVALUATION DATA BASE

FIGURE 6.1–2 SUMMARY OF MACS SIMULATIONS PERFORMED OVER THE LAST FIVE YEARS

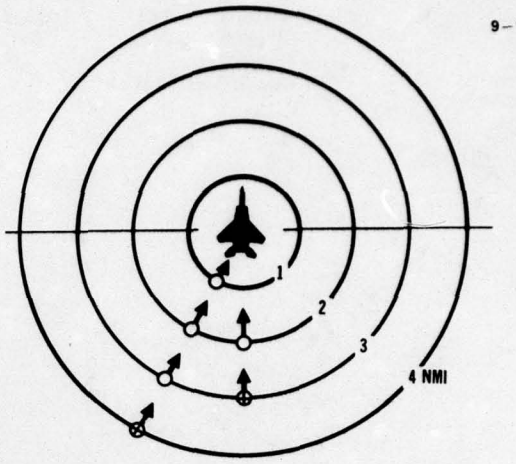
[2]Other instruments and CRT display capability for radar, IR, LLLTV and moving map simulations, as well as warning lights and switches, are available in the cockpits for special purpose simulations. Full manual controls are included in the cockpit with realistic force gradients and an active trim switch. Physiological cues are also incorporated into the cockpit to simulate g load, buffet, sound, and blackout-grayout.

[3]Of the 35 studies, nine were concerned with missiles or exotic weapons evaluation, or used a two-on-one scenario. Of the remaining simulations, a number were engineering evaluations and did not have formal reports detailing the pilot performance data or the procedures of the simulation study. Others did not have reports complete enough for the type of analysis we required (12 studies). Three additional studies were not issued in time for inclusion in this analysis.

with air-to-air combat evaluations of the capabilities of the F-15, the AV-8A, and a group of advanced design aircraft.

6.1.1.2 The F-15 Simulation - The F-15 simulation consisted of a one-on-one, close-in, air-to-air, guns-only combat between the F-15 and representative enemy fighters. Test objectives were to obtain data within a controlled test environment of the F-15's air superiority over the two types of threat aircraft. This simulation involved the F-15's pilot/weapons system interface, aircraft maneuvering, crew station controls and displays, the fire control system and the internal M61A1 cannon. The F-15 was flown in two configurations, an all-up mode in which all systems functioned and a back-up mode in which selected systems were assumed to be down.

To minimize variability from extraneous sources, a balanced test was defined where four pilots selected by the F-15 Special Projects Office alternated in flying both the threat and F-15 aircraft. Each test period simulated up to six minutes of combat and was initiated at one of two altitudes (10,000 or 30,000 feet). Each engagement began with one or another of the aircraft having a positional advantage and overtake speed (see Figure 6.1-3). The variables were systematically varied to control test biases.



INITIAL CONDITIONS
O- 10,000 FEET CO-ALTITUDE
⊕- 30,000 FEET CO-ALTITUDE

DEFENDER AT 0.85 MACH

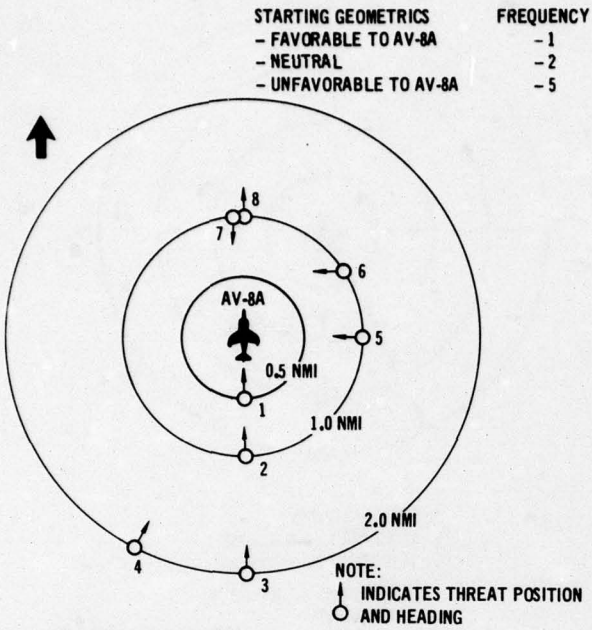
ATTACKER RANGE, NMI	SPEED
1	1.05M (1132 FPS)
2	1.15M (1240 FPS)
3	1.22M (1315 FPS)
4	1.29M (1390 FPS)

NMI - NAUTICAL MILES
FPS - FEET PER SECOND
M - MACH
INDICATES AIRCRAFT POSITION

FIGURE 6.1-3 THIS FIGURE ILLUSTRATES THE STARTING CONDITIONS WHICH HAVE BEEN USED FOR THE F-15 CLOSE-IN MANNED AIR COMBAT ENGAGEMENTS

The total test schedule (which was preceded by a five-day indoctrination and training period) involved 129 air-to-air combat engagements over a four-day period. The primary objective of each pilot, as defined by test procedures, was to maximize his kill advantage over his opponent. To this end, he could maneuver and fire freely within the constraints of his fuel, his ammunition load, and the limits of his aircraft's flight capabilities.

6.1.1.3 The AV-8A Simulation - The AV-8A (Harrier) simulation consisted of a series of three separate simulations each having three friendly and two threat pilots and making a total of nine friendly and six threat pilots. As all three simulations were essentially replications of the same study, they will be considered together. These simulations engaged the AV-8A against the Fresco C (MIG-17) and Fishbed J (MIG-21) in one-on-one air combat. The objectives of the simulation program were to provide data on thrust vector control effectiveness and maneuver effectiveness. Overall, the major question was whether a subsonic, thrust vectored aircraft could survive against a high performance supersonic threat aircraft. Each AV-8A pilot received two days of familiarization within the combat environment and then four days of intensive one-on-one training against threat aircraft manned by experienced pilots. Primary emphasis was



ALL ENGAGEMENTS BEGIN WITH:
- –AV-8A AND THREAT AT 10,000 FT ALTITUDE
- –AV-8A WITH 60% INTERNAL FUEL
- –THREAT WITH 75% INTERNAL FUEL

INITIAL CONDITION	FAVORABLE TO	INITIAL MACH			
		AV-8A	FRESCO (MIG-17)	AV-8A	FISHBED (MIG-21)
1	THREAT	0.70	0.85	0.85	1.02
2	THREAT	0.70	0.85	0.85	1.05
3	THREAT	0.70	0.90	0.85	1.15
4	THREAT	0.70	0.90	0.85	1.15
5	THREAT	0.70	0.85	0.85	1.05
6	– *	0.70	0.70	0.85	1.05
7	– *	0.70	0.70	0.85	1.05
8	AV-8A	0.85	0.70	0.85	0.70

*FISHBED HAS ENERGY ADVANTAGE

FIGURE 6.1-4 THIS FIGURE ILLUSTRATES THE INITIAL CONDITIONS WHICH HAVE BEEN USED IN THE AV-8A MANNED AIR COMBAT ENGAGEMENTS

on AV-8A defensive maneuvers. A small percentage of training was given for offensive maneuvering, and each AV-8A pilot was given an opportunity to fly both threat aircraft. One-on-one combat was initiated from eight starting conditions - five of which placed the AV-8A at a disadvantage. All engagements were characterized by close-in hard maneuvering. The number of engagements and amount of time spent against each threat were nearly equal as intended in the counterbalanced experimental design. All pilots flew against the threat aircraft and pilots an equal number of times from an ordered sequence of starting conditions (see Figure 6.1-4). In all, 427 one-on-one engagements were flown with a maximum duration of three minutes. The data analysis considered missions having a duration of more than 150 seconds as completed.

6.1.1.4 Advanced Design Aircraft Simulations - The last group of simulations involved advanced concept aircraft in a one-on-one situation involving both real and conceptual threat aircraft. The advanced design concepts were the High Acceleration Cockpit (HAC), the Vectored Lift Fighter (VLF) and the Advanced Fighter Technical Integration (AFTI) (see Figure 6.1-2). The HAC incorporates a reclined seat which allows a significant increase in pilot g tolerance. This concept was demonstrated to be very effective and is currently being implemented in an aircraft for flight testing. The VLF incorporated concepts allowing for direct fuselage aiming and directional changes through vectored thrust, making it a highly maneuverable aircraft. The AFTI incorporated a number of new technologies including the vectored thrust concept, the high acceleration cockpit and a number of new avionics concepts. As was the case with the other simulations, a balanced design was used throughout, allowing each pilot to fly all aircraft against all other pilots under a variety of starting geometries. In all cases, instructions were given that aggressive air-to-air combat was to be initiated, although, in some cases, the development aircraft was so superior to the threat that avoiding being shot down was the best the threat could hope for.

6.1.2 The Differential Maneuvering Simulator at NASA, Langley, Virginia - The Differential Maneuvering Simulator (DMS) at the National Aeronautics and Space Administration (NASA), Langley Air Force Base, Hampton, Virginia, was reviewed as part of our evaluation of air combat simulators as possible selection test instruments for identifying combat effective fighter pilots. The DMS, which began operation in 1971, makes it possible to study the interactive maneuvering of two vehicles (and pilots)

as they perform in a variety of air combat engagements. The facility was developed to provide NASA, Langley with simulation capabilities that would work in conjunction with other NASA research facilities and complement the work of the design groups, wind-tunnel, and flight research projects. Operations have concentrated on one-on-one air combat maneuvering investigations with the objective of systematically studying advanced, novel, or innovative concepts of aircraft and systems that could improve the combat effectiveness of future fighter aircraft (Meintel, Pennington, and Hankins, 1973).

6.1.2.1 Facility Description - The system was based on the use of available state-of-the-art components (circa 1968). It consists of two 40-foot diameter projection spheres each housing a cockpit and projection system, interface control consoles, and two image generating systems. The system provides a 350° field-of-view and extends from directly overhead to 60° below the horizon except for those areas occluded by the aircraft nose.[4] Controls are loaded to represent proper control feedback and force characteristics. Opponent aircraft and relevant ground cues are projected on the inner surface of the spheres (see Figure 6.1-5).

The system does not include a vertical motion capability although up to one q buffet can be induced on the cockpit. Additional flight cues such as sound, rudder pedal shaker, g-suit

[4]Vision immediately behind the pilot is occluded by the target equipment (see Figure 6.1-5).

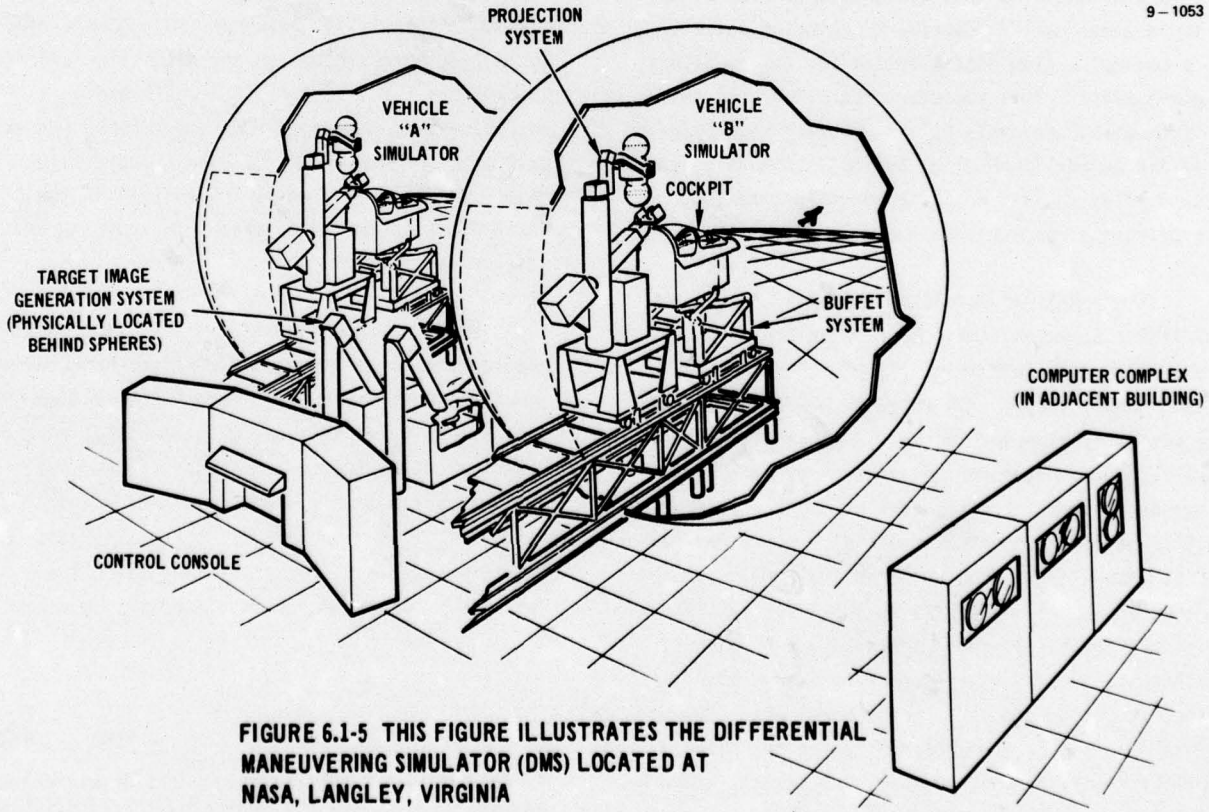


FIGURE 6.1-5 THIS FIGURE ILLUSTRATES THE DIFFERENTIAL MANEUVERING SIMULATOR (DMS) LOCATED AT NASA, LANGLEY, VIRGINIA

inflation, and blackout are also provided. Significant improvements have been made in the simulation hardware as the need has become evident. An updated HUD was added in early 1976. On-line missiles were added in 1975, and on-line guns were added in late 1975.[5] These features provide on-line firing information and feedback to the pilot regarding weapons utilization - an important factor in realistically simulating air-to-air combat.

The design and analysis aspects for the simulation studies run on the DMS are handled by a single group which has generated a standard set of performance scores, standard test designs and comprehensive computerized data reduction packages which allow efficient date reduction and analysis (see Appendix 6.A).

6.1.2.2 Adaptive Maneuvering Logic Model - NASA, Langley, as part of its program on interactive air-to-air combat, has developed a computer logic model called Adaptive Maneuvering Logic (AML) to control a simulated aircraft for combat with a human pilot. This computer-controlled opponent or "iron pilot" not only allows a better understanding of air combat maneuvering but can serve as a standard pilot against which to evaluate training, proficiency maintenance, and selection procedures.

The model was developed in conjunction with Decision Sciences, Inc., to replace the pilot in one of the two spheres of the DMS (Burgin, Fogel, and Phelps, 1975). The model is based on flying a series of maneuver segments which are continually updated based on the flight maneuvers of the opponent aircraft. The model predicts the future state of its opponent from its past position. The best maneuver is then selected from the possible maneuvers, based on a 12-item logic system evaluating the positional advantage achieved by each alternative. The highest scoring alternative is then executed, and the process continues. The update occurs once every second making the "iron pilot" highly responsive to the opponent's maneuvering. The scores from the 12-item AML positional advantage evaluation are also used as a composite criterion of pilot performance called Adaptive Maneuvering Logic Scores (AMLS). A full description of the AML is found in Appendix 6.B. The AML Model has been used with a number of pilots and has achieved good acceptance as a realistic and competitive opponent (Hankins, 1976).[6] The basic model as reported here has been continually upgraded, and a new version is scheduled for inclusion in the Manned Air Combat Simulator being developed by McDonnell Douglas for the Navy's upcoming air-to-air combat training simulation program located at the Naval Training Equipment Center, Orlando, Florida (the Navy's 2E6 program).

6.1.3 The Simulator for Air-to-Air Combat at Luke Air Force Base, Arizona - The Simulator for Air-to-Air Combat (SAAC) at Luke Air Force Base, Arizona, was evaluated for its applicability as a tool for pilot selection. Built by Singer-Link for use by the Tactical Air Command (TAC) as a training system for air combat and air combat tactics development, its role has since been expanded to include aircraft design and dissimilar aircraft comparisons. The installation was based on a requirement documented in September 1965, and was delivered to Luke Air Force Base in July 1975. It is presently being used by TAC as well as the Air Force Systems Command to meet both training and research objectives.

6.1.3.1 Facility Description - The SAAC is a two-cockpit, interactive Basic Flight Maneuvering and Air Combat Maneuvering (BFM & ACM) motion-based trainer employing advanced CRT technology to produce the out-of-the-cockpit scenes. The system is limited to air-to-air segments of the flight regime using the forward cockpit of an F-4 aircraft. No provisions are made for simulating takeoff and landings. Major components of the system are:

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[5]Personal communication with the NASA simulation group.

[6]Data from 12 typical pilots flying a lightweight fighter against the AML indicated that the AML won in 35 of the 72 engagements flown. (Personal communication from W. W. Hankins, NASA, Langley, 1976).

two F-4 cockpits; a Xerox Sigma Five Computer; an instructor and operator console; g onset simulation capability (g-suit, seat and blackout cues); a hydraulic motion system; and a multi-screen CRT display system to simulate the out-of-the-cockpit scene (see Figure 6.1-6). The display system simulates a 246° by 150° outside field-of-view of the target aircraft, sky, horizon and terrain. The terrain consists of a four-shades-of-gray matrix of 1/2 mile squares, with adjacent squares having different gray shades. The horizon appears as an unfocused band between earth and sky. The target aircraft is generated from a gimbal mounted model approximately one foot in length. This entire display is viewed through an optical glass window which focuses the CRT images at infinity. Some problems were found with the resolution available on the CRTs during ACM in that at distances greater than one mile range, aspect angles were very difficult to determine (Steward, 1976). The capability of the CRT display to resolve images is about 1/4 to 1/2 of that of the eye (DCS Tactics Analysis and Development, 1976). This resolution mismatch is a *major* deficiency in the simulator if it is to be used as a selection tool for ACM capability. It also is a significant limitation on training for ACM. Improvements for this function will be dependent on advancements in the state-of-the-art of CRT displays.

9-1132

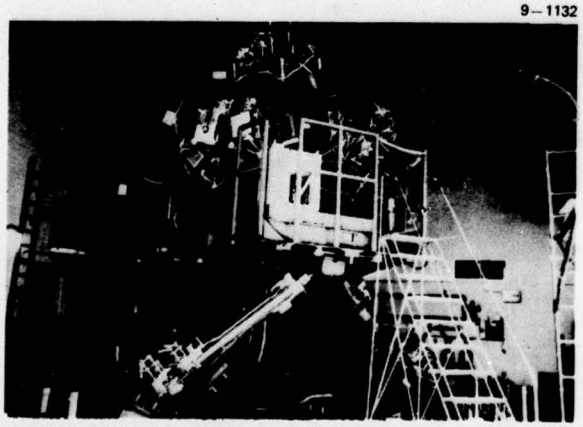


FIGURE 6.1-6 SIMULATOR FOR AIR-TO-AIR COMBAT AT LUKE AIR FORCE BASE, ARIZONA

The cockpits are connected to a digital computer and can be programmed with the performance characteristics of any U.S. or Soviet aircraft, although currently the target model is limited to the F-4. Thus, while the opponent aircraft may fly like a MIG, it will look like an F-4. The computer can simulate avionics, weapons, and design changes and modifications as the software becomes available. At present, no software experts conversant with the system are organic to the installation at Luke.

The motion capability allows six degree of freedom movement through the use of six linear hydraulic actuators arranged in sets of three pairs. These actuators can provide both positional and acceleration cues to the pilots.

6.1.3.2 Research - Because of the relatively recent delivery of the SAAC, no research directly relatable to pilot selection has been performed. However, an analytical review (Stewart, 1976) of the system and a transfer of training study, TAC ACES II (see DCS Tactics Analysis and Development, 1976), to evaluate the capability of the SAAC as a training device, were performed. The results of both these studies indicated several severe deficiencies in the SAAC as a training instrument, although the overall impression was that the SAAC would serve a useful training function once the deficiencies were corrected.

Measures taken in the TAC ACES II study were based on those obtained from TAC ACES I, a study by LTV using the Vought Air Combat Simulator (VACS) (Roberts, 1976). Data on individual pilots were not available for any of these measures.[7]

[7]Three maneuvers were evaluated: a stabilized tracking run; a high angle raking shot run; and an ACM maneuvering sequence. Details of the three maneuvers can be found in DCS Tactics Analysis and Development, 1976. Two complete runs were made for each of the first maneuvers and one of each for the three options for the ACM maneuver. The data obtained for each maneuver are listed in Figure 6.1-7.

Overall, the SAAC could be used for pilot selection provided a number of deficiencies can be corrected. These include an upgraded visual system, software experts organic to the SAAC, appropriate target models, and an improved system reliability to allow for efficient utilization of the system.

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DATA REQUIREMENT	MANEUVER NUMBER		
	1	2	3
(1) PILOT ID NUMBER.	X	X	X
(2) MANEUVER NUMBER 1, RUN NUMBER.	X	X	X
(3) AIM-9 LAUNCHED, NOT LAUNCHED, BY RUN.		X	
(4) AIM-9 KILL, MISS, BY RUN.		X	
(5) NUMBER OF 20 MM HITS, BY RUN.	X	X	
(6) NUMBER OF 20 MM EXPENDED, BY RUN.	X	X	X
(7) PERCENT OF 20 MM HITS/EXPENDED, BY RUN.	X	X	
(8) TOTAL AIM-9s LAUNCHED.		X	X
(9) TOTAL AIM-9 KILLS.		X	
(10) TOTAL 20 MM HITS BY BOTH RUNS.	X	X	
(11) TOTAL 20 MM EXPENDED FOR BOTH RUNS.	X	X	
(12) PERCENT OF HITS EXPENDED FOR BOTH RUNS.	X	X	
(13) TIME FROM 90° ASPECT TO KILL.			X
(14) TYPE OF WEAPON USED FOR KILL.			X

FIGURE 6.1-7 DATA REQUIREMENTS FOR THE THREE MANEUVERS USED IN TAC ACES I AND II

6.1.4 The Advanced Simulator for Undergraduate Pilot Training at Williams Air Force Base, Arizona - The Advanced Simulation for Undergraduate Pilot Training (ASUPT) located at Williams Air Force Base, Arizona, became operational in January 1975.[8] The ASUPT consists of two T-37B jet trainer cockpits and was designed as a training and research tool for undergraduate pilots. It is the first simulator developed specifically as a behavioral science tool for application to pilot training research, and, in that respect, is one of the most sophisticated simulators available.

6.1.4.1 Facility Description - The basic cockpits are programmed to simulate ground operations, normal and abnormal flight conditions, aerobatic flight, formation flying, and post-stall and spin. An air-to-air combat capability was not originally built into the system as the T-37B is not considered an appropriate aircraft for fighter operations. In principle, the system could fly air combat simulations, but significant modifications would have to be made to both the cockpit and the system software to include the required weapons systems. Although the ASUPT was developed independently of the SAAC (Simulation for Air-to-Air Combat, see Section 6.1.3), they have many features in common. This is not surprising as they both were developed by the same company (Singer) during the same time frame. Both use the same type of motion induction system (ASUPT has an additional hydraulic actuator for safety purposes) and a display for out-of-the-cockpit viewing dependent on computer-generated CRTs. The entire visual scene is computer-generated, including the image of other aircraft. The scene is viewed by the pilot through a fisheye lens. The visual system consists of seven CRTs plus optics giving a mosaic field of view of ±150° horizontal and +110°, -40° vertical. Special systems were developed as the low efficiency of the optics required exceptionally high brightness in the CRTs.[9]

The brightness requirements eliminate any true color capability using current technology. The ASUPT also has extensive provisions for modified operation by instructor pilots. These include both an in-cockpit station (the second cockpit set has an instructor console), a conventional controller station, and a special advanced controller station. In addition, computer-controlled Advanced Instructional Provisions (AIP) are available which enable the instructor to insert preselected malfunctions into the simulated aircraft. This system also has provisions for a computer-controlled course of instruction allowing automatic sequencing of AIP.

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[8]This description is based on a series of reports entitled, Advanced Simulation in Undergraduate Pilot Training, AFHRL-TR-75-59, Vol. I to VII, Air Force Systems Command, Brooks AFB, Texas, June 1975.

[9]The specially developed CRTs, said to be the largest in the world, have a total radiation output of over 10,000 lumens and provide 1,000 raster lines at a brightness of between 630 and 840 foot lamberts, about the brightness of a 50-watt bulb, (AFHRL-TR-75-59, Vol. I, 1975).

A full description of this system can be found in a series of Air Force Human Resources Laboratory reports (AFHRL-TR-75-59, Vols. I - VII, 1975). These descriptions are currently being updated, and the new report should be released before the end of 1977.

6.1.4.2 Research - The ASUPT serves four major purposes:

1. Determination of the effects of simulator configurations on training, e.g., effects of motion and visual field on teaching students to fly.

2. Motion-g seat-vision interactions using experienced pilots to evaluate simulator design configurations.

3. Development of design for A-10 and A-6 simulations.

4. Development of engineering requirements to allow the most cost effective design of future training simulators.

A number of studies relating to these purposes have been performed including evaluations of A-10 simulator requirements and an air-to-ground transfer of training study. Neither of these studies has been published yet, but personal communications with Dr. Thomas Gray at Williams Air Force Base have indicated significant improvement in air-to-ground ordnance delivery following simulator training. Interestingly, better training occurred using ASUPT as a fixed base rather than a moving base simulator. The simulator motion appeared to degrade transfer of training. Similar problems with motion were indicated by Rust (1975) while evaluating the ASUPT as a training device. With this exception, and a few comments concerning specific control "feel," the ASUPT seems to provide a very realistic and useful training device. It would have highly limited use as a system for pilot selection because of the problems in the out-of-the-cockpit display and the lack of a weapons systems capability.

6.1.5 Reliability of Simulator Performance Measures - The adequacy of air combat maneuvering simulators (ACMS) as a means of evaluating pilots for combat effectiveness is dependent on two major factors: how well the simulator yields reliable measures of performance; and the extent to which these measures are valid predictors of combat proficiency. This section is concerned with the reliability of the measurements used in the existing ACMS.

Reliability, of course, refers to the capability of a measuring instrument to yield consistent values when measuring the properties of objects or people. It requires that the measuring tool be consistent and that the property being measured has characteristics which can be measured. For simple physical measures (length, duration), this relation is clear cut; an ACMS measuring pilot combat proficiency presents a more difficult case. Within the context of this study, our first priority is to establish whether the ACMS yields consistent measures of pilot performance.

6.1.5.1 Mechanical Reliability - ACMSs consist of large integrated groupings of computer hardware and software, as well as mechanical and electrical interfaces. Because of this complexity, subtle subsystem changes can significantly degrade system reliability while the system is, to all appearances, still functioning perfectly. To combat this unreliability, "calibrations" are made on major subsystems prior to each series of runs. This, in effect, compares the simulator against a standard. In the MACS, for example, reliability is established with programs which calibrate the alignment of the electro-optical and electro-mechanical linkages and the control display interfaces. Sights and head-up displays are optically inspected for alignment. With the advent of digital simulation, software programs maintain a high degree of reliability (once thoroughly debugged) and are seldom a source of errors. These or equivalent procedures assure that most simulators will produce reliable data, short of having some catas-

trophic failure which shuts down the entire system.[10] Mechanical reliability, once achieved, is reflected in the operational performance of the simulator. During a recent simulation, the F-15, exhibiting its air superiority capability, achieved better performance than the threat aircraft for all measures of pilot performance across all pilots. In some cases, the same pilot achieved score ratios as great as 100:1 between his performance scores with the F-15 aircraft and threat (McDonnell Douglas Report MDC A1455, 1972). Similar consistencies were found with NASA simulations evaluating empirical estimates of aircraft capability (the Aircraft Maneuvering Parameter) and non-weapons oriented measures of aircraft performance (Beasley and Beissner, 1974).

6.1.5.2 Measurement Reliability - The aspects of reliability dealing with the characteristics of the thing to be measured are much more subtle. Pilot proficiency is generally considered to be a result of some combination of factors including the personality and the physical, perceptual and cognitive capabilities of the individual. Like intelligence, it is an implied attribute which is defined by scores on the measuring instrument itself. Thus, a pilot who wins frequently in the air-to-air simulation is considered to have more proficiency than one who loses frequently. This, of course, must later be validated against an outside criterion such as ACMR/I performance or actual combat. Such validation procedures, along with the relationship between simulator and criterion performance, will be discussed later in the section dealing with validity.

Because of the interactive nature of air-to-air combat, a degree of uncertainty is associated with the outcome of any engagement. For any given run, the more proficient pilot has a higher probability of winning; however, his winning is not a certainty. Additionally, the data can have a degree of non-transitivity so that pilot A can beat pilot B, and pilot B can beat pilot C, but pilot C can win over Pilot A. This occurrence may be a sampling problem; although it is possible that pilot C has a unique maneuver that works with pilot A but not with pilot B. This pilot by maneuver interaction, should it be the true explanation, is an example of the variability which can occur in a complex, interactive competition between individual pilots.

The variability inherent in the task tends to distribute the scores around some mean which can be considered the best estimate of pilot proficiency. Because of the high degree of variability found in pilot performance measures from ACMS, a fairly large sample of scores must be obtained before a stable estimate of an individual's capability can be obtained. Given such a sample for a number of pilots, the reliability of a performance measure, called a reliability coefficient, can be estimated through the use of correlational statistics. These statistics yield estimates of how close a pilot's score will correspond with a second score taken under the same conditions.[11] If the degree of correspondence is high, the measuring tools used to obtain the scores can be considered to generate reliable estimates of the pilot's capability.

6.1.5.3 Performance Measures and Data Generated by AMCS - The analysis of effective performance of any simulation depends on the capability of the system to produce reliable objective response measures which relate to overall performance. The simulations run at McDonnell Douglas in the MACS

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[10]Such breakdowns are, unfortunately, all too frequent due to the complexity of the system. In some cases like the SAAC (Stewart, 1976), they have compromised the usefulness of the ACMS.

[11]The scores, of course, must be taken under near identical conditions to keep sources of extraneous variation to a minimum. One of the best techniques for meeting these requirements is to obtain the reliability coefficient through the split-half technique. This technique takes one half of a series of measurements and correlates it against the other half. Scores can be assigned to halves on an "odds" to one half, "evens" to the other, or on the basis of a counterbalancing scheme where each half has scores taken under as near identical circumstances as possible.

have typically used 11 such measures of performance. The simulations analyzed for this study have used from four to seven of these measures (see Figure 6.1-8) as criteria for evaluating air combat effectiveness. The criteria, for the most part, can be considered as a series of sequentially dependent tasks with a final criterion of probability of kill (P_K). These criteria are, in order of dependence, expanded gun envelope,[12] gun envelope, gun fire time or rounds fired, type 2 hits (those within 20 feet of the opponent's center of gravity), type 1 hits (those within 10 feet of the opponent's center of gravity), and P_K. In addition we have values for theoretical Type 1 and Type 2 hits which indicate the average time hits would have been made had the gun been fired. All these measures are obtained through either direct timing of operations, calculating the time an aircraft falls within a set of parameters or calculating the projected path of the bullets given the flight paths and other variables relating to the two aircraft.

9-1071

MEASURES	AV8A	HAC	F-15	VLF	AFTI
TIME IN EXPANDED ENVELOPE	X				
TIME IN ENVELOPE	X		X		
OFF OR ADVANTAGE TIME		X			
GUN FIRE TIME	X	X			X
ROUNDS FIRED		X	X	X	
T_1 (10 FT CG) HITS	X	X	X	X	X
T_2 (20 FT CG) HITS	X	X	X	X	X
THEORETICAL T_1 HITS	X				
THEORETICAL T_2 HITS	X			X	
P OF KILL		X			X
TIME TO 1ST SHOT				X	

FIGURE 6.1-8 PILOT PERFORMANCE MEASURES USED IN THE SIMULATIONS RUN AT MCDONNELL DOUGLAS

As shown in Figure 6.1-8, the only consistent measure across the MACS simulations were Type 1 and Type 2 hits. This lack of consistency of criteria underscores a pervasive problem in evaluating simulation studies. There are no existing standardized performance criteria for measuring pilot proficiency. New sets of performance measures are generated independently for each simulation. This lack of consistency makes the cross-evaluation of a group of simulations extremely difficult as there are often few, if any, common measures to analyze.

6.1.5.4 Performance on the McDonnell Douglas Manned Air Combat Simulator - The data obtained from the seven MACS simuilations are shown in Figures 6.1-9 through 6.1-13 (the three AV-8A simulations are grouped together). Examining these data, it becomes obvious that large differences in performance exist within a given simulation across a number of performance measures.

In the case of the HAF study (see Figure 6.1-11), Pilot 1 consistently has the lowest scores across all measures except Type 1 gun hits. The differences are large and consistent enough to make this pilot a candidate for transfer out of a fighter program. Pilots 1 in the VLF simulation (see Figure 6.1-12) and 3 in the AFTI simulation (see Figure

9-1072

	GUN ENVELOPE	ROUNDS FIRED	T_1 HITS	T_2 HITS
PILOT 1	4.69	310	4.55	18.89
2	4.82	265	2.31	8.92
3	3.51	223	9.17	28.52
4	4.31	266	5.45	18.28
MEAN	4.33	266	5.37	18.65
STANDARD DEVIATION	0.61	35.52	2.86	8.01

FIGURE 6.1-9 AVERAGE VALUES, OVERALL MEANS AND STANDARD DEVIATIONS FOR PERFORMANCE MEASURES USED IN F-15 SIMULATIONS

[12]Normal gun envelope consisted of a tracking error of within ± 3°, angle-off target tail of less than 30° and a range of under 3,000 feet. The expanded gun envelope was included for the AV-8A tests because of the low frequency of gun envelope solutions during the conduct of the simulation. This expanded gun envelope consists of a tracking error of less than ± 5°, 30° angle-off target and a range of under 3,000 feet.

6.1-13) show consistent superiority over all measures taken. In all three cases, the sample size is not large enough to compute meaningful statistics. In addition, all measures (with the exception of time to fire and offensive time) relate to gun firing and hits. Reviewing the data from the F-15 simulation, (see Figure 6.1-9) which included time in gun envelope measures, we observed reversals in performance between gun envelope and hits data, i.e., the best pilot on the hits measure, pilot 3, was the worst on the time in gun envelope measure. The same kind of reversal is found in the AV-8A simulation for pilot 4 (see Figure 6.1-10). The inconsistencies in performance, between time in gun envelope, rounds fired, and hits can be accounted for by a number of testable hypotheses. Among these are the effective use of high deflection shots and firing only at close range, where maximum hits are achieved. Despite these occasional anomalies, however, the general trends of the data show that some pilots are clearly superior to others. To illustrate these trends, the data relating to the AV-8A simulations, which contain the largest pilot group run in the MACS (see Figure 6.1-10), were reworked into performance rankings (see Figure 6.1-14). This figure shows consistent and clear differences between the best and poorest pilots. Pilots, 8, 2, 11, and 14 all rank consistently in the top third, and pilots 9, 6, 10 all rank in the lower third. Some interesting hypotheses on critical skills can also be obtained from these data by analyzing factors such as gun time versus hits (efficiency) and actual hits versus theoretical hits. The later measure may be a good indicator of gunnery skills and a good discriminator between pilots (see pilot 1 versus pilot 8, in Figure 6.1-10).

9-1073

PILOT	GUN ENVELOPE	EXPANDED GUN ENVELOPE	GUN TIME	T_1-HITS	T_2-HITS	THEORETICAL T_1 TIME	THEORETICAL T_2 TIME
FRIENDLY							
P1	0.13	4.95	0.47	0.42	1.23	0.01	0.07
P2	0.13	6.85	1.21	0.17	0.96	0.01	0.09
P3	0.07	4.08	0.39	0.10	0.25	0.02	0.06
P4	0.03	4.49	1.74	0.14	0.83	0.01	0.09
P5	0.00	2.60	1.50	0.00	0.39	0.00	0.03
P6	0.02	2.06	0.28	0.00	0.00	0.00	0.02
P7	0.03	4.42	0.96	0.05	0.34	0.01	0.04
P8	0.18	8.64	1.90	0.33	1.48	0.04	0.14
P9	0.00	1.13	0.06	0.00	0.00	0.00	0.00
MEAN	0.66	4.36	0.95	0.13	0.61	0.01	0.06
STANDARD DEVIATION	0.66	2.34	0.68	0.15	0.54	0.01	0.04
THREAT							
P10	0.24	6.06	1.92	0.38	2.58	0.03	0.17
P11	0.48	11.84	1.89	0.43	3.00	0.06	0.25
P12	0.50	6.77	1.52	0.13	0.64	0.01	0.04
P13	0.47	8.67	2.07	0.71	2.90	0.05	0.18
P14	0.69	9.38	1.42	0.91	2.37	0.06	0.19
P15	0.54	8.24	1.01	0.44	2.18	0.04	0.15
MEAN	0.32	5.66	1.09	0.33	1.52	0.03	0.11
STANDARD DEVIATION	0.27	4.54	0.88	0.33	1.33	0.03	0.10

FIGURE 6.1-10 AVERAGE VALUES, OVERALL MEANS AND STANDARD DEVIATIONS FOR PERFORMANCE MEASURES USED IN AV-8A SIMULATIONS

9-1074

PILOT	EXPECTED KILL	GUN TIME	ROUNDS	T_1 HITS	T_2 HITS	OFFENSIVE TIME
P1	0.084	0.203	138.8	2.95	3.63	47.06
P2	0.204	0.406	327.5	3.03	9.14	66.27
P3	0.212	0.403	223.9	1.71	6.90	59.10
P4	0.211	0.600	263.1	4.36	11.86	59.32
MEAN	0.178	0.537	231.6	3.01	7.88	57.94
STANDARD DEVIATION	0.064	0.162	102.3	1.08	3.49	7.98

FIGURE 6.1-11 AVERAGE VALUES, OVERALL MEANS AND STANDARD DEVIATIONS FOR PERFORMANCE MEASURES USED IN HIGH ACCELERATION FIGHTER (HAF) STUDY

9-1075

PILOT	ROUNDS	T_1 HITS	T_2 HITS	TIME TO FIRE
P1	271.7	15.59	78.27	81.8
P2	152.2	5.59	31.00	108.4
P3	197.4	5.53	37.02	96.2
P4	191.4	4.05	18.87	104.2
MEAN	203.2	7.69	41.28	97.7
STANDARD DEVIATION	49.9	5.31	25.82	11.7

FIGURE 6.1-12 AVERAGE SCORES, OVERALL MEANS AND STANDARD DEVIATIONS FOR PERFORMANCE MEASURES USED IN THE VECTORED LIFT FIGHTER (VLF) SIMULATION

9-1076

PILOT	GUN TIME	T_1 HITS	T_2 HITS	EXPECTED KILL
P1	2.76	3.08	12.88	0.033
P2	2.18	2.25	7.46	0.039
P3	4.04	5.25	14.17	0.091
MEAN	2.99	3.53	11.50	0.054
STANDARD DEVIATION	0.95	1.55	3.56	0.032

FIGURE 6.1-13 AVERAGE SCORES, OVERALL MEANS AND STANDARD DEVIATIONS FOR PERFORMANCE MEASURES USED IN THE ADVANCED FIGHTER TECHNICAL INTEGRATION (AFTI) SIMULATION

Because of the constraints of the simulation studies, subject groups were highly limited in size. Differences in aircraft capability and study design prevented our summing over subjects to generate a sample size adequate for meaningful statistical inference. Attempts were made to apply multiple regression techniques to the data; however, no meaningful results were obtained except to identify pilots as a significant factor in predicting overall performance. This means that a significant amount of the variability in the scores can be attributed to individual differences in the pilots. The variability inherent in this set of scores and the small sample size effectively prohibited further analysis of these data.

9-1077

PILOT	GUN ENVELOPE	GUN TIME	HITS	THEORETICAL HITS
FRIENDLY				
1	3	6	2	5
2	2	4	3	2.5
3	5	7	7	4
4	4	2	4	2.5
5	8	3	6	7
6	7	8	8.5	8
7	6	5	5	6
8	1	1	1	1
9	9	9	8.5	9
THREAT				
10	6	5	4	4
11	1	4	1	1
12	5	3	6	6
13	4	6	2	3
14	2	2	3	2
15	3	1	5	5

FIGURE 6.1-14 RANK ORDERING OF PILOT PERFORMANCE ON SELECTED PROFICIENCY MEASURES FOR AV-8A SIMULATION

6.1.5.5 Performance on the NASA Differential Maneuvering Simulator - To date, over 150 pilots have been used in tests run in the Differential Maneuvering Simulator (DMS). Pilots are typically run in groups of four with a completely balanced design directed at evaluating one or two design parameters for a given aircraft. The simulation group at NASA made available to us performance data on 12 pilots flying a lightweight fighter type aircraft using the most recent on-line gun and missile programs. The data come from equivalent aircraft baseline runs. In addition to kills and losses, summary data were available for three non-weapons-oriented dependent variables routinely used by NASA to evaluate pilot performance: time-on-

offense (TO); time-on-offense with advantage (TOA) (Beasley and Beissner, 1974); and a composite AML score[13] (see Figure 6.1-15).

9—1078

PILOT	TIME ON OFFENSE*	TIME ON OFFENSE WITH ADVANTAGE*	AMLS*	KILLS*	LOSSES*
1	56.5	17.1	4.6	2	4
2	56.3	25.5	5.1	1	8
3	81.3	38.3	6.2	7	1
4	73.0	25.3	5.2	5	2
5	128.7	71.6	6.1	3	1
6	88.5	30.2	4.9	1	4
7	99.3	28.9	5.3	4	0
8	91.2	11.0	4.6	0	3
9	62.8	15.3	5.0	3	6
10	79.5	34.5	5.8	7	0
11	68.2	16.2	4.6	1	4
12	87.6	35.3	5.3	3	4
MEAN	81.08	29.10	5.22	3.1	3.1
STANDARD DEVIATION	20.42	16.00	0.56	2.31	2.43

*AVERAGE 12 ENCOUNTERS

FIGURE 6.1-15 MEAN SCORES, OVERALL MEANS AND STANDARD DEVIATIONS FOR PERFORMANCE MEASURES USED IN NASA DIFFERENTIAL MANEUVERING SIMULATOR, LANGLEY, VIRGINIA

These data represented a sample large enough to yield meaningful statistical analysis and were, therefore, used to evaluate the reliability of the DMS measures.[14] For each measure a split-half reliability coefficient (see Figure 6.1-16) and the standard error of measurement based on six trials were calculated. Using these values, if the simulation were repeated, the number of kills per man for a set of six trials, should not differ by more than one 85% of the time.[15] Put another way, the odds of having a score on a repeated simulation which differs from the present score by more than one are 5:1 against. For the AMLS data, the odds against having a score on a replication which differs by ± .5 are better than 20:1. The TO and TOA measures are far more variable and do not appear to be reliable discriminators of individual performance, given the relatively small sample size used in these studies (six runs). These measures are also general indicators of pilot capability with an implied relationship to the ultimate criterion, i.e., kills. The AMLS measure correlates well with kills ($r = .79$); and as a measure of positional advantage, it is also a good indicator of the pilot's flying capability relative to the position and flying capability of his opponent. It is important to note that high AMLS scores (eight or better for a given one second interval) usually indicate that you are in or near a firing position. The AMLS presents a reasonable alternative to kills. Such alternatives are often required, especially when using dissimilar aircraft where the inferior aircraft can achieve few if any kills. This type of situation occurred several times during the MACS simulations forcing the use of a nonkill criterion to evaluate the outcome of a simulation. Our analysis indicates that both direct (kills) and indirect (AMLS) measures exist which can reliably measure pilot capability in a simulator.

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[13]Time-on-offense consists of the cumulative time during a run when a pilot has the opponent's aircraft in front of his aircraft's wing line. Time-on-offense with advantage adds the additional restriction that the pilot is behind the opponent's wing line (in his rear hemisphere). This index provides an offense-and-not-defense indicator (you can potentially shoot him but he can't shoot you). The AMLS is based on the logic of the AML model mentioned previously (Burgen, Fogel and Phelps, 1975) and represents the average of the summed scores of the maneuvering decision criterion which is obtained every second. This was developed in the AML model to indicate relative positional advantage between aircraft. A description of the model and this decision criterion are given in Appendix 6.B.

[14]Scores were taken on a by-mission basis using equal aircraft and a neutral starting condition. All groups of four pilots flew a balanced set of 24 runs, where each pilot flew two runs against every other pilot in the group and used both DMS spheres. This yielded a total of six runs per pilot for each simulator sphere and provided the sample of performance and a balanced test design required to evaluate the capabilities of the pilots in a completely fair manner.

[15]The reliability coefficient is an index of how well you are measuring what you want to measure. It represents the amount of variance in the second score which can be accounted for by knowing the first score. The error of measurement is based on the degree of correlation (the value of the reliability coefficient) between the two sets of scores and is an estimate of how close you will come to the same score if you repeated the measurement. For example, you will obtain a score within a range of ± one standard error 68% of the time and within ± two standard errors 95% of the time.

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MEASURE	TO		TOA		AMLS		KILLS		LOSSES	
DMS SPHERE	A	B	A	B	A	B	A	B	A	B
PILOT 1	52.1	60.8	17.6	16.6	4.5	4.5	1	1	3	1
2	42.9	69.7	16.7	34.3	5.1	5.1	1	0	4	4
3	101.5	61.0	54.9	29.7	6.0	6.3	2	5	1	0
4	84.2	61.7	34.7	15.8	5.4	5.0	2	3	1	1
5	117.7	139.7	60.5	82.6	5.9	6.2	2	1	1	0
6	107.4	69.5	42.2	18.2	5.3	4.5	1	0	0	4
7	91.3	107.3	25.9	31.9	5.3	5.3	2	2	0	0
8	86.1	96.2	7.9	14.0	4.5	4.6	0	0	2	1
9	41.7	83.9	7.9	22.6	4.9	5.1	2	1	2	4
10	82.9	76.0	42.3	26.7	6.0	5.6	3	4	0	0
11	98.3	38.1	29.7	2.7	4.9	4.2	1	0	2	2
12	84.8	90.4	31.1	39.5	5.2	5.3	2	1	2	2
MEAN	82.6	79.5	31.0	27.9	5.3	5.1	1.58	1.50	1.50	1.58
STANDARD DEVIATION	24.7	26.5	17.0	20.0	0.52	0.66	0.79	1.67	1.24	1.62
RELIABILITY COEFFICIENT	0.27		0.55		0.82		0.78		0.56	
PERCENT OF VARIANCE	7%		30%		67%		61%		31%	
STANDARD ERROR	21.40		12.74		0.25		0.60		1.31	

FIGURE 6.1-16 RELIABILITY COEFFICIENTS, MEANS, STANDARD DEVIATIONS AND STANDARD ERROR VALUES FOR THE SPLIT HALF RELIABILITY TESTS OF THE DATA GENERATED IN THE NASA DMS

6.1.5.6 Utilization of Performance Measures to Discriminate between Pilots - These measures can also be used to discriminate among pilots. Reviewing the data, we find large differences in individual performance for kills, losses and AMLS measures (see Figure 6.1-17). Using the reliability coefficients generated for these measures, it is possible to estimate the probability that different scores could represent the same level of pilot capability, and all differences in scores are measurement errors. Evaluating the data we found the probability of the scores being random error is approximately one in 27,900 when comparing the two highest and the four lowest kill values.[16] Similar values are obtained for the highest and lowest scores on the other measures, although the differences in some cases are between different pilots. While this can be a serious problem in selecting the proper criteria to evalute the pilots, this particular set of data shows a clear superiority for the two top pilots. It would be difficult to make a reliable estimate of which of these two was the "best," but this would be true of almost any measure of individual capability where two individuals are nearly evenly matched. Using these data for selection, two of twelve pilots are clearly superior, and four of twelve are poor risks. Based on this simple simulation exercise, about 18% of the pilot population could be selected as superior in ACM and 25% as inferior. Considerable refinement is necessary before a final test of capability could be defined; however, the data generated indicate that such a test would be quite feasible.

9-1080

PILOT	AVERAGE KILLS (A + B)/2	AVERAGE LOSSES (A + B)/2	AMLS
A	3.5	0.0	5.8
B	3.5	0.5	6.2
C	2.5	1.0	5.2
D	2.0	0.0	5.3
E	1.5	0.5	6.1
F	1.5	2.0	5.3
G	1.5	3.0	5.0
H	1.0	2.0	4.6
I	0.5	2.0	4.9
J	0.5	2.0	4.6
K	0.5	4.0	5.1
L	0.0	1.5	4.6
MEAN	1.54	1.54	5.22
STANDARD DEVIATION	1.15	1.21	0.56
STANDARD ERROR OF MEASUREMENT	0.49	0.80	0.24

FIGURE 6.1-17 RELATIVE PERFORMANCE BY KILL/LOSS RANKING AND AMLS MEASURES. STANDARD DEVIATION AND STANDARD ERROR OF MEASUREMENT ARE INDICATED TO ILLUSTRATE THE POTENTIAL CHANGES IN SCORES

[16] A new standard error (SE) of measurement was generated based on the standard deviation of the average scores (per six trials) for each pilot. Based on the distribution of standard errors, scores greater than ±2.77 standard errors will only occur once in every 167 times. Using this value and the SE of .54 found for this sample, pilots A and B will achieve kill scores of roughly 2.0 only once in every 167 times. By the same logic, subjects I, J and K will achieve scores as high as 2.0 with the same frequency. The probability of both these occurring in the same sample by chance alone is about 1 in 27,900 indicating a high probability that the higher scorers and the lower scorers have truly different capabilities.

6.1.6 The Validity of Air Combat Maneuvering Simulators as a Measuring Tool for Air Combat Proficiency - Like reliability, there are two important aspects of validity as they pertain to simulators; does the simulator fly like the actual aircraft (mechanical validity) and are the better fliers the high scorers in the simulators (operational validity). The best measure of this would be performance in combat which matched performance in the simulator. Achieving this kind of validity requires an extensive aerial conflict on the level of World War II or Korea. Vietnam, despite all its aerial activity, had only limited air-to-air combat, and opportunity became a significant issue. The next level of validity would be a comparison between simulator performance and performance in the ACMR/I. Due to the recent completion of these facilities, data relating simulators and the ACMR/I are very scarce. The data that do exist, however, will be evaluated in connection with both flight tests and the ACMR/I.

6.1.6.1 The Mechanical Validity of the Simulation - Designers of the simulations discussed in this section have taken great effort to ensure that they are mechanically valid, that is, they have the same control and flying characteristics as the aircraft they represent within the limits of the simulator mechanization and software. The techniques used for refining the control feel and flying characteristics of the simulator incorporate a mixture of objective engineering and subjective pilot opinion. The objective data usually are generated by extensive flight test programs and provide a baseline approximation of the flying characteristics. This baseline is then fine-tuned by experienced pilots to produce a system which flies and feels exactly like the aircraft. A good example of how this refining process is accomplished is documented by Captian S. K. Rust in his article on Simulator Fidelity Assurance (1975) which deals with the system validation of ASUPT at Williams Air Force Base, Arizona.

"The first problem was input. In fact, there are a lot of holes in the available aerodynamic data for the T-37B, particularly in the stall, post-stall, spin, and control loading areas. Much of the basic aerodynamic data came from the T-37A, which is a slightly different model with different aero characteristics. To fill in these data gaps (basically areas where the fidelity of simulation was unsatisfactory) the simulator was "tweaked" (as has been done with every simulator that I know of). The tweaking game has three players, the pilot, the contractor, and the simulator. Pilots tweak, or fine-tune, the simulator to make it feel or respond like the aircraft. For instance, if aileron stick force at low airspeed is too heavy, a coefficient can be changed to adjust it. These pilot suggested changes (called tweaking) are a 50/50 deal at best. While the pilot is tweaking the simulator, the simulator is tweaking the pilot. For example, a pilot climbs into the simulator and, for a given airspeed (230K), the aileron stick force for a given stick deflection is too heavy; let's say it is five pounds heavier than it should be. So the pilot says, 'Aileron is too heavy.'

"The contractor (who is on the simulator's side) says, 'Are you sure? Our data shows that the simulator is matched exactly to the aircraft.'

"Pilot says, 'No, I'm sure it's too heavy.'

"Contractor says, 'OK, I'll change it, but I know what we've got in there meets the test guide.' With that, he changes the force so it is only three pounds too heavy. The pilot flies the device and, lo and behold, it really feels a lot better; still not quite right, but just a little too heavy.

"So the contractor decreases it to two pounds too heavy. The pilot again flies and says, 'I'm pretty sure that's right.'

"Now what happens? The pilot goes home, sleeps, flies the aircraft early in the morning, comes in that afternoon to work on a different problem, jumps in the simulator and takes off. The pilot calls the contractor and says, 'Hey, this thing is really mixed up. Why did you increase the aileron force again?' So now, the contractor is wondering if the pilot has got his landing gear on straight and, instead of decreasing the aileron force when requested, he increases it to see if the pilot can really tell the difference . . . and the tweaking games go on. It's very inefficient, but currently it's the only way to fill the data gaps." (Rust, 1975, p. 108)

A number of problems exist with this technique due to the subjective nature of the "it feels right" response. Pilots should shuttle between the "real" and simulated cockpits to ensure they stay in touch with a proper reference point. In addition, the reactions of "new" pilots should also be solicited as with simulator practice, a given pilot loses sensitivity to the differences between the aircraft and the simulation. These and the problems of identifying subtle but important miscues in the simulator are the greatest problems with subjectively refining the system. Once again, Rust's own experience provides a first hand example of the process.

> "However, after a period of time our ability to detect small control discrepancies was limited because both John and I could fly the simulator very precisely the way it was. Therefore, John and I would fly with new IPs occasionally to observe their performance and to record their comments. We then interpreted this information to the contractor, and eventually got the simulator to perform closer and closer to the real aircraft.
>
> "One of the most complex problems we ran into was correlation of the different sensory cues to which a pilot is attuned. Control, feel, motion, visual, g-seat and aural cues must all be provided to the pilot very accurately. None of these components works alone, and most can't be evaluated separately. For instance, it is extremely difficult to evaluate control loading if motion is giving incorrect cues. Incorrect motion cueing causes abnormal control inputs; abnormal control inputs magnify the motion problem, etc. Now a cue may detract from the total simulation in two ways -- one, if it's an inaccurate cue, or two, if it occurs at the wrong time." (pp.108-109).

Similar procedures and problems were found with the validation of the other simulators studied. In these cases where the aircraft represented a concept rather than hardware, existing baseline aircraft software was modified to incorporate the new maneuvering capabilities. The pilots then "tweaked" the system to produce the best handling characteristics possible, within the constraints of the design concept.

Validation studies have concentrated on pilot performance with respect to the aircraft flight envelope and the maneuvers performed during ACM, rather than comparisons of individual pilot capability on both the simulators and the ranges. These data provide indirect evidence of simulator validity, in that, if the aircraft are performing equivalent maneuvers, the pilots are operating the same way in both situations. This is only secondary validation, as the question of whether the pilots would perform as well in both situations is still unanswered.

A three-phase study was conducted to establish the validity of the NASA DMS. The first phase consisted of replications of the aircraft evaluation flight test on the simulator, comparing simulated aircraft response with flight-test results. The results of this test showed a good match between plots of the flight test data and the simulator aircraft responses for most of the aerodynamic characteristics (Meintel, et al, 1973).

The second phase related to the aircraft feel while performing a series of tracking maneuvers. A comparison of these tracking maneuvers, as shown in Figure 6.1-18, indicated good agreement between

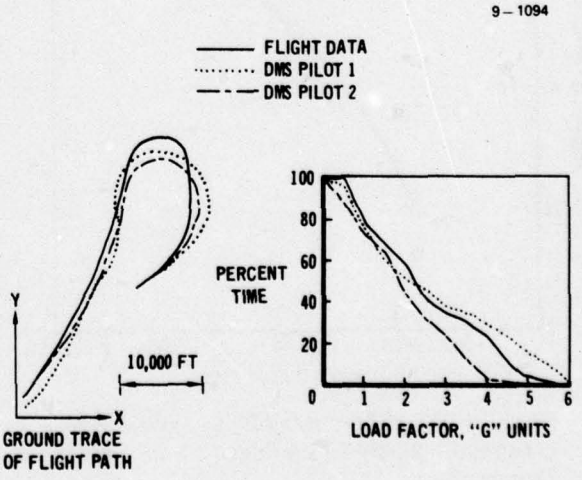


FIGURE 6.1-18 COMPARISON OF FLIGHT AND SIMULATOR DATA FOR EXECUTION OF TRACKING MANEUVERS

the simulator runs and the results obtained from the flight program.

The third phase of the validation was to conduct an experimental program to evalaute the relationship between flight and simulated ACM. The Air Force conducted a study in 1967 to generate ACM data to serve as a comparison for simulations of air-to-air combat. This program, "Combat Hassle" (Krajeck, 1968) consisted of a series of one-on-one air combat engagements between two aircraft, one of which had its thrust capabilities limited to two-thirds, one-third or military thrust. This parametric study was repeated in the DMS and the results were compared with the "Combat Hassle" data. The probability of conversion (putting the sight on the target) as a function of thrust is shown in Figure 6.1-19. As can be seen from the figure, the relative results are in quite good agreement.

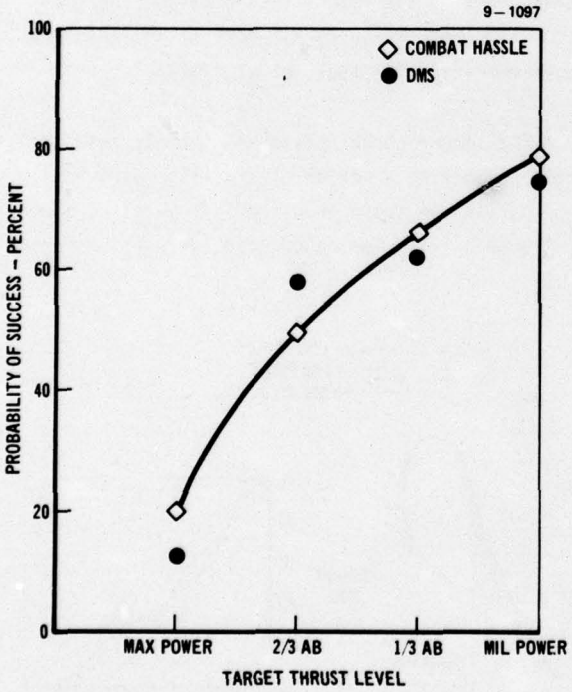


FIGURE 6.1-19 PROBABILITY OF CONVERSION BY STANDARD AIRCRAFT AS A FUNCTION OF TARGET THRUST LEVEL

The three phase validation program seen on the DMS lead to the conclusion that, ". . . current fighter aircraft can be represented with useful accuracy, and pilot operation in the simulator can be meaningfully compared in a similar operation in flight. The results of a research type study conducted in the simulator compare favorably with flight results." (Meintel, et al, 1973, p. 17)

A similar validation was performed for the McDonnell Douglas F-15 simulation using flight test data from ACMR, and Edwards AFB, California (Jacezko, 1976). These flight tests consisted of a limited number of one-on-one mock air combat engagements between the F-15 and other aircraft. A comparison of several aircraft parameter measures are shown in Figure 6.1-20. Good agreement is shown between the simulator and flight test data.

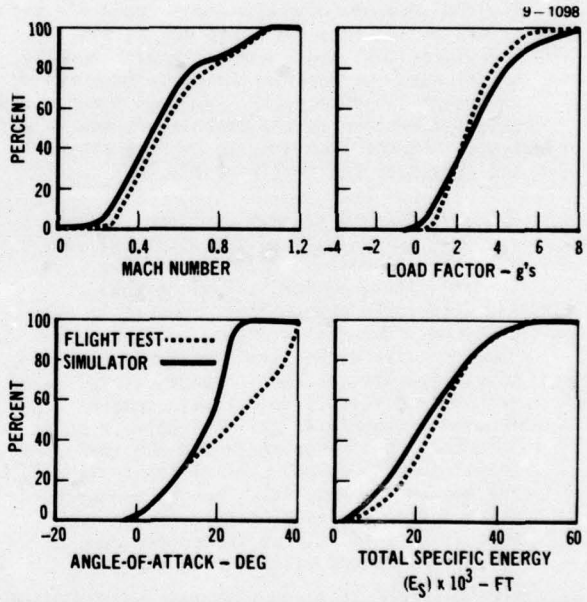


FIGURE 6.1-20 COMPARISON OF SIMULATOR AND FLIGHT TEST FLIGHT PROFILES FOR SELECTED MEASURES

An even more striking demonstration of simulator validity, with respect to flight performance, occurred during the "Streak Eagle" time-to-climb program in which several climbing records were set. Due to simulator inputs, the original flight profile for the time-to-climb record flight was modified into the profile actually used in setting the record (see Figure 6.1-21). The actual times to

reach specific altitude barriers were also predicted by the simulator with remarkable accuracy (see Figure 6.1-22).

The limited data available directly comparing flight tests and simulators appears to strongly support the validity of the simulator with respect to the flight performance characteristics of the aircraft and to some extent the maneuvering characteristics during aerial combat engagements. A significant amount of work is needed, however, relating specific pilot capabilities from the simulator to actual flight. The advent of the instrumented ranges at Yuma and Nellis opens up the possibility of such comparisons in a cost effective manner. These ranges will be discussed in Section 6.2.

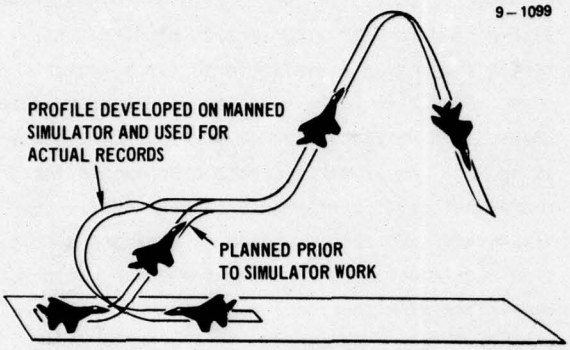


FIGURE 6.1-21 ORIGINAL AND SIMULATOR MODIFIED TIME-TO-CLIMB FLIGHT PROFILES

9-1100

ALTITUDE (METERS)	MANNED SIMULATOR (SEC)	ACTUAL RECORD (SEC)
3,000	28	27.57
6,000	39	39.33
9,000	49	48.86
12,000	59	59.38
15,000	78	77.02
20,000	131	122.94
25,000	175	161.02
30,000	228	207.80

FIGURE 6.1-22 COMPARISON OF SIMULATOR PREDICTIONS AND ACTUAL TIME-TO-CLIMB TO AN ALTITUDE

6.1.6.2 Validity of the Simulator with Respect to Pilot Performance - The problem of performance validity is much harder to deal with than the problem of system validity. Not only is there no actual combat against which to evaluate simulator performance, there is very little organized data to evaluate with respect to the simulators themselves. Most simulation experiments do not record the flying histories of the pilots used as subjects.

In an attempt to verify the relationship between pilot capability and simulator performance, performance history questionnaires were developed and mailed to the 15 pilots participating in the AV-8A simulation. Of the 15 questionnaires distributed, 13 were returned, seven for the friendly and six for the threat pilots. The responses to this questionnaire were used to rank the pilots with respect to their total flight hours, the number of ACM engagements that they had participated in, and the number that they had won (see Figure 6.1-23). These values were then compared with the rank ordering of performance for the Time in Envelope, Gun Hits and Theoretical Gun Hits measures obtained in the AV-8A simulation (see Figure 6.1-14). A Spearman Rank Correlation was used to make these comparisons (Siegel, 1956).

The Spearman Rank Correlation coefficients for all combinations of performance measures are shown in Figure 6.1-24. Of the 8 correlation coefficients shown, only one approaches statistical significance, the hits by percent wins comparison for the friendly pilots (.683 where significance, [α = .05] is equal to .714).[17] The obtained correlations coefficients are of moderate size and several would be significant if the pilot population on which they were based were larger. While these data are illustrative of the kind of analysis

[17]the significance levels (α = .05) for this statistic for an "n" of six and seven observations are .829 and .714, respectively.

needed to evaluate simulator performance and objective indices of pilots skill, no statistically meaningful conclusions can be made. The values do indicate, however, that future analyses of this type should concentrate on the relationship between hits, Time in Envelope, and the estimated percent of previous ACM wins.

9-1092

PILOT	NUMBER OF FLIGHT HOURS	RANK ORDER	NUMBER OF ACM ENGAGEMENTS	RANK ORDER	PERCENT WINS	RANK ORDER
FRIENDLY						
1	1800	5	250	4	80	2.5
2	2350	3	150	2	70	4
3*	—	—	—	-	-	-
4	3000	2	150	5	67	5
5	1200	6	500	3	80	2.5
6*	—	—	—	-	-	-
7	1100	7	100	6	50	6
8	3500	1	1600	1	90	1
9	2000	4	15	7	30	7
THREAT						
10	1600	3	600	3	70	4
11	1600	3	300	5.5	90	2
12	1600	3	500	4	50	6
13	3100	1	300	5.5	67	5
14	1400	5	1500	1.5	80	3
15	1250	6	1500	1.5	99	1

*THESE PILOTS DID NOT RETURN COMPLETED QUESTIONNAIRES

FIGURE 6.1-23 FLIGHT HISTORY AND RELATIVE PROFICIENCY OF PILOTS PARTICIPATING IN THE AV-8A SIMULATION

9-1093

FRIENDLY PILOT			
	GUN ENVELOPE	HITS	THEORETICAL HITS
FLIGHT HOURS	0.304	0.335	0.509
ACM ENGAGEMENTS	0.411	0.603	0.455
PERCENT WINS	0.295	0.683	0.304
THREAT PILOT			
	GUN ENVELOPE	HITS	THEORETICAL HITS
FLIGHT HOURS	-0.275	0.429	0.200
ACM ENGAGEMENTS	0.0	-0.486	-0.257
PERCENT WINS	0.657	0.257	0.371

FIGURE 6.1-24 CORRELATION BETWEEN PILOT PERFORMANCE MEASURES FROM THE AV-8A SIMULATION AND INDEPENDENT ESTIMATES OF PILOT ACM PROFICIENCY

Short of actual combat validation, the ACMR/I appears to be the best way to generate data on a pilot's ACM capabilities. While it is possible to approach this problem from a historical perspective and generate the required data from existing records, this approach has many drawbacks. Illustrative of these drawbacks are the difficulties encountered in analyzing the MACS simulation data (see Section 6.1.5). The success of this approach also depends on detailed records of ACMR/I performance being made available to the research team. Plans are being made for an automated data storage and retrieval system for the ACMR, however, at present, no systematic data base exists for individual pilot performance on the ACMR/I. An alternative approach would be to design a special simulator and flight test program which would get comparable pilot performance measures under comparable flight conditions. This program would have to conform to strict mission control procedures and follow an outline of specific confrontation rules. One part of such a program is currently being carried out on the ACMI at Nellis Air Force Base. This program, ACEVAL-AIMVAL is a highly controlled series of air-to-air engagements whose purpose is to evaluate flight tactics and missile concept effectiveness. A parallel program using a simulator will provide the kind of data necessary to better evaluate the relationship between flight and simulator performance.

6.2 AIR COMBAT MANEUVERING RANGE/INSTRUMENTATION

The results of the Air War over Vietnam in the late 60s indicated a need for some type of advanced pilot training in air-to-air combat (Weapons Systems Evaluation Group, Red Baron II, 1973a, 1973b). Based on the premise that the best training for air combat was flying air combat-like missions in a controlled environment, and the fact that technological advances made possible the real-time monitoring of such missions, the Navy Air Combat Maneuvering Range (ACMR) and the Air Force Air Combat Maneuvering Instrumentation (ACMI) facilities were constructed.[18] These facilities provide aircrew training in a realistic but controlled environment in which the student can repeatedly observe the effectiveness of simulated weapons released under the conditions encountered in an air combat engagement. The system tracks aircraft operating within an assigned airspace, and computes and displays position, attitude and weapons-related parameters of the aircraft. These are presented in real time, using a three-dimensional representation of the engagement. This display can be monitored by instructors during the engagement and played back later to the pilots to identify errors in tactics or weapons release. The facilities provide the capability to monitor and record the results of a multi-aircraft mock combat engagement through the use of a specially instrumented pod mounted on the aircraft and strategically placed special ground based radar tracking stations. Used with aircraft having the maneuvering characteristics of the MIG, this system allows the pilots to "hassle" with aircraft which maneuver like the enemy. This is done in an environment where mistakes are analyzed and reviewed instead of buried[19]. While no one fully equates even a realistic training arena with the stress of real combat, useful flying skills can be developed which will improve a pilot's combat capability. With this in mind, the overall emphasis of the facilities is to train for accurate, real time weapon envelope recognition capability during ACM. The following sections describe the basic systems advantages and limitations of both the Navy ACMR and the Air Force ACMI.

6.2.1 Description of the ACMR, Yuma, Arizona - The original ACMR was installed at the Marine Corps Air Station, Yuma, Arizona and became operational in December, 1973. Full utilization was not reached until early 1976 because of a lack of a full complement of airborne instrumented pods.[20] This system was set up to track four high-speed aircraft from altitudes of 5,000 to 40,000 ft. within a 30-mile cylinder. It can also maintain surveillance on an additional 12 aircraft within a 50-mile diameter cylinder.

6.2.1.1 ACMR Training Modes - Five training modes are used to support different levels of pilot training. These modes are outlined in Figure 6.2-1. As can be seen from the figure, these modes are based on an orderly progression of difficulty. This progression was meant to assist the student to develop progressively increasing proficiency in recognizing, and maneuvering to, the weapons launch envelope.

6.2.1.3 ACMR Functional Subsystems - The ACMR consists of four major subsystems: aircraft instrumentation subsystem (AIS); tracking instrumentation subsystem (TIS); control and computation subsystem (CCS); and display and debriefing subsystem (DDS). The AIS pod replaces a sidewinder missile on one of the launch racks. This subsystem collects data on

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[18] The Ault Committee Report (NAVAIR SYS COM, 1969) indicated that poorer than expected air combat performance in Southeast Asia was primarily due to training deficiencies and failure to recognize weapons performance boundaries under combat stress. Formation of the Navy Fighter Weapons School at Naval Air Station Miramar as the Navy pilots' "graduate" school for tactics, weapons and ACM training (The Top Gun Program) was one action resulting from these findings. As another action, Air Test and Evaluation Squadron FOUR (VX-4) was requested to define the requirements for an ACM test range (Johns Hopkins University, 1976).

[19] When first flying against the F-5 aggressor aircraft, the new F-4 pilots typically try to turn with the "enemy," despite warning to NEVER TRY TO OUT TURN A MIG. In combat, this is a potentially fatal error in judgement. On the ACMR they learned, by experience, not to do it.

[20] Tests of an improved production pod were made in late 1974, but the full complement of pods was not delivered until early 1976.

9-1083

MODE	CUE	REQUIREMENTS
1	CONTINUOUS TONE WHEN IN FIRING ENVELOPE	AIRCRAFT WITHIN RULE-OF-THUMB WEAPONS FIRING ENVELOPE.
2	TONE IF PROPER LAUNCH IS EXECUTED	AIRCRAFT WITHIN RULE-OF-THUMB WEAPONS FIRING ENVELOPE. SCORED ON BASIS OF CORRECT LAUNCH.
3	CONTINUOUS TONE WHEN IN FIRING ENVELOPE	COMPUTED WEAPONS FIRING ENVELOPE BASED ON CONTINUOUSLY COMPUTED AIRCRAFT/MISSILE PARAMETERS.
4	TONE IF PROPER LAUNCH IS EXECUTED	COMPUTED WEAPONS FIRING ENVELOPE BASED ON CONTINUOUSLY COMPUTED AIRCRAFT/MISSILE PARAMETERS. SCORE IF LAUNCH IS IN ENVELOPE AT TIME OF TRIGGER PULL.
5	TONE IF PROPER LAUNCH IS EXECUTED	MORE COMPLEX PROGRAM. TAKES INTO ACCOUNT TARGET MOTION. ALLOWS DEFENSIVE MANEUVERS. SCORE ONLY IF "GOOD" HIT IS ACHIEVED. HAS DYNAMICS OF THE "REAL WORLD."

FIGURE 6.2-1 THIS FIGURE LISTS THE FIVE TRAINING MODES USED IN THE ACMR/I. THEY REPRESENT AN ORDERED PROGRESSION IN DIFFICULTY FROM ROUGH ENVELOPE APPROXIMATION TO THE BEST ESTIMATE OF HITS WITHIN THE LIMITS OF ACMR/I ACCURACY.

aircraft and pilot performance and transmits it to the ground via an air-to-ground data link. These data include tracking information, weapons selection, radar lock-on, aircraft attitude, altitude, acceleration, angle of attack, and airspeed.

The above data are obtained in part from the TIS. The TIS consists of a network of small, sun-powered units controlled by a master station. The subsystem is capable of locating aircraft utilizing any three remote stations. A ground-to-air link permits crosstalk between the pods and the ground station. A ground link also connects the remote stations with the main CCS. The CCS contains the data reduction hardware and software necessary to determine the position of each aircraft on the range and the weapons envelope for the selected training mode. It also determines whether the range safety requirements are being met and issues warnings to aircraft violating the restrictions. The CCS also provides real-time recordings and displays both inter- and intra-aircraft parameters for up to four aircraft. There are two DDSs, one at Yuma and one at Miramar Naval Air Station in California. These facilities contain instructor monitoring stations with real-time displays of the status of all the aircraft. The displays can present both an alphanumeric status report on an aircraft by aircraft basis and a number of special visual representations of the combat area. These include an out-of-the-cockpit (pilot's perspective) view for any of the aircraft, and a 3D representation of the combat as a whole centered around a selected position in space. The latter 3D view can be rotated to present the engagement from different viewpoints. The same capability exists for presenting the engagement to the student pilots during off-line debriefing sessions. The purpose of the ACMR, as it was first constructed, was to be a training facility. It was not intended as an instrumented system for development and evaluation. The potential for this was so great, however, that the system was rapidly developed into an evaluation facility - often at the expense of training missions. As early as 1974, evaluations of the effectiveness of the F-15 in the air superiority role were conducted at the ACMR. These data were also used to evaluate the accuracy of the MACS F-15 simulation with respect to both performance and software programs (Jacezko, 1976). Despite the restrictions of the ACMR data collection system, it was a major breakthrough in real-time flight monitoring and the only system then available able to collect interactive, in-flight, aircraft, performance data.

6.2.2 The Air Force Air Combat Maneuvering Instrumentation Facility - The Air Combat Maneuvering instrumentation (ACMI) is essentially an improved and technologically updated replica of the ACMR. The ACMI became operational in July 1976. It provides an aircraft control and real-time display capability for up to eight high-activity and 12 low-activity aircraft engaged in ACM. Like the ACMR, the ACMI was designed to provide a facility for pilot training; however, because it offered

the best available system to document ACM,[21] it was selected for use in the Air Combat Evaluation-Air Intercept Missile Evaluation (ACEVAL-AIMVAL) program. This joint Air Force-Navy program will evaluate Air Combat capability and the use of new air intercept missiles for the F-14 and F-15 aircraft against the F5A, a MIG-like opponent.

6.2.2.1 General System Description of the ACMI - The ACMI airspace is a cylinder 30 nautical miles in diameter extending from approximately 5000 feet above the average ground level to 40,000 feet mean sea level located on the Nellis AFB south ranges. It employs a seven-station, inertially aided, multi-station tracking system coupled to a computer and display system through microwave communication links. Real-time recordings replayed through remote displays at the training base provide immediate postflight crew debriefing and analysis. The airborne component of ACMI is a pod in AIM-9 configuration which mounts on a standard launch rail providing a transponder for the multi-station system and data link for transmission of aircraft attitude, weapon status, and barometric data to ground computers. Weapons scoring is based on missile miss distance calculations performed in the ground computers by means of digital simulations. The system accommodates any inventory Missile configuration, provided suitable firing signals are available to the pod, and is suitable for use with F-4, F-5, F-8, F-14, F-15, F-111, A-4, A-6, and A-7 aircraft. .

The basic ACMI is organized into the same four subsystems as the ACMR: the AIS pod, the TIS, the CCS, and the DDS. The functional arrangement of these systems is depicted in Figure 6.2-2.

Seven TIS remote tracking stations were installed on the Nellis south range and communicate with the master station on Angel Peak through ground-to-ground transceivers. The master station communicates with the CCS via microwave data links. Although the basic ACMI DDS is permanently installed within Building 102 at Nellis AFB, the CCS and added DDS are situated in vans alongside the building. Point-to-point and air-to-ground-to-air communications are provided via the various links for command and control of the mission exercises and data transmissions.[22]

The accuracy of ACMI system parameters and the range of the dynamic parameters to be measured are found in Figures 6.2-3 and 6.2-4, respectively.

6.2.2.2 Changes in ACMI Instituted for ACEVAL-AIMVAL - A missile simulation subsystem (MSS) and one additional DDS were added to the basic ACMI. The MSS allows for a doubling of the simultaneous missile launch capability to a total of eight. The extra DDS allows for necessary separate debriefing facilities for the Red (F-5E pilots) and Blue (F-14 and F-15 pilots) Forces and offers a backup control DDS during primary DDS downtime.

A number of additional modifications were made, all of which tend to increase the data acquisition and data reduction capability of the ACMI. In general, these modifications consist of the inclusion of gun firing data into the ACM, increased information channel capacity from the AIS pods, software to calculate missile probability of launch and kill, an additional Sigma 9 computer, and an expanded data display for mission status monitoring and mission debriefing. A comparison of ACMR and ACMI changes is summarized in Figure 6.2-5. A comprehensive description of the ACMI facility as modified for ACEVAL-AIMVAL may be found in ACEVAL-AIMVAL Test Plan (1976, Vol. III).

6.2.3 ACMR/I Evaluation as a Selection and Performance Measurement Tool - Pilot opinions of the facility as a training device have been highly

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[21] High-activity aircraft are defined as those actually engaged in ACM for which all position, maneuvering, and weapons data are required. Low-activity aircraft are those for which x and y position information only is required. Provisions for low-activity aircraft were included in the ACMI to permit up to eight fighters to escort up to 12 bomber or similar strike aircraft.

[22] The preceding descriptions were taken from the ACEVAL-AIMVAL Final Test Plan, Vol. IV, August 1976.

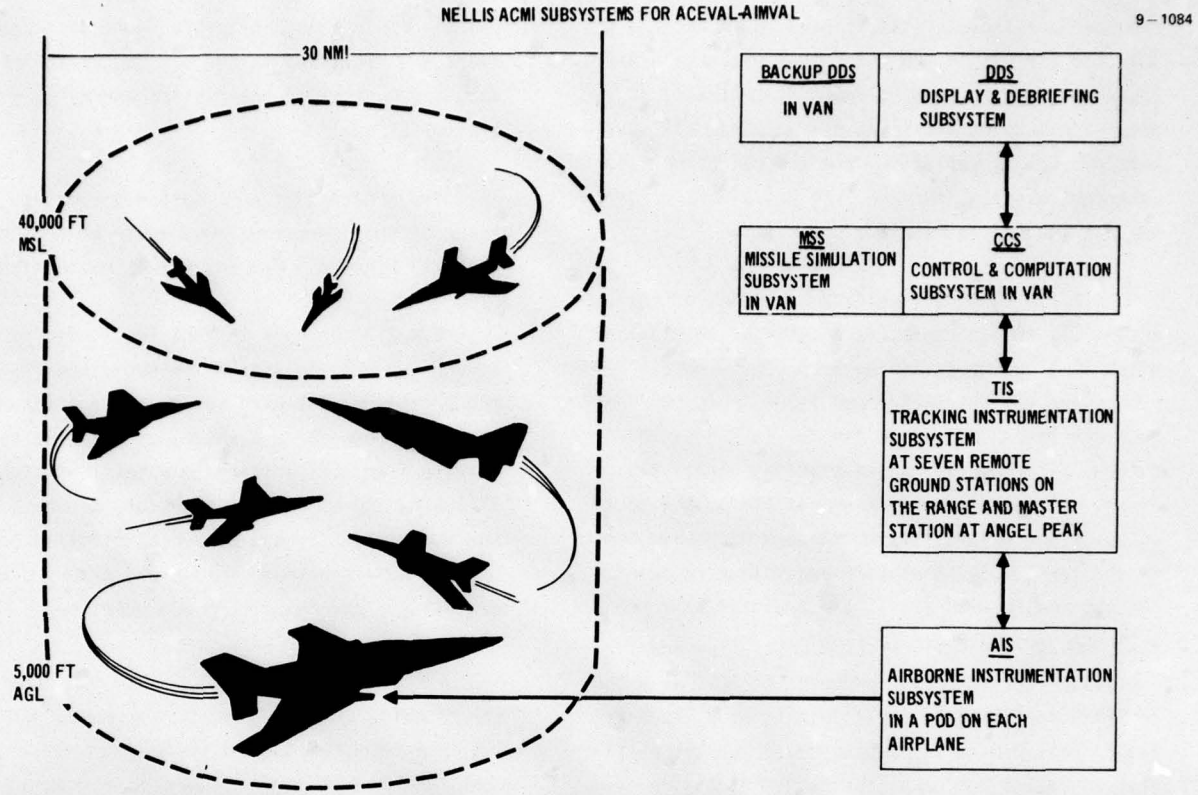


FIGURE 6.2-2 THE FUNCTIONAL ARRANGEMENT OF THE NELLIS ACMI SUBSYSTEMS AS THEY EXIST FOR THE ACEVAL-AIMVAL PROGRAM

favorable, especially from those who have had experience with the system. Figure 6.2-6 lists some of the general comments regarding the benefits of ACMR/I training which we received from our pilot questionnaire. Of the pilots who responded to this question, over 98% had favorable comments.

In addition to a pilot evaluation of the utility of the ACMR/I as a training tool, we specifically asked the pilots to rate the facility as a tool for selecting both combat-effective pilots and those pilots who would not be combat-effective (see Figure 2.8-1).

In reply to the question "Do you feel the pilots who perform well in the ACMR/I will perform well in actual air-to-air combat?" Sixty-five percent of the combat pilots agreed or strongly agreed, 23 percent had no opinion, and only 12 percent disagreed or strongly disagreed. In answer to the question, "Do you feel pilots who perform poorly in the ACMR/I will do poorly in actual air-to-air combat?" Fifty-four percent agreed or strongly agreed, 26 percent had no opinion, and 20 percent disagreed or strongly disagreed. These responses indicate highly favorable pilot opinions of the ACMR/I as a selection tool for combat effective pilots. Pilot opinion also indicates that the ACMR/I may be useful as a tool to cull out those pilots of low combat effectiveness. The reservations which do exist in both of these areas center around some of the basic characteristics of the range, Despite the utilization of actual aircraft in an environment of high speed, interactive maneuvering, the encounters on the range are not real combat. At best, they can train or measure whether a pilot knows what to do and if he is capable of doing it. There is no technique incorporated into the range to measure whether he will use those capabilities when engaged in actual combat. This

9-1085

ACMI PARAMETRIC DATA	MAXIMUM STANDARD DEVIATION OF ERROR
1. CLOSING VELOCITIES BETWEEN "FIGHTERS" AND "TARGETS" (V_C)	35 FT/SEC
2. SLANT RANGES FROM "TARGETS" TO "FIGHTERS" (ΔR)	50 FT
3. ASPECT ANGLE (ASA)	2 DEG
4. ASA IN WING PLANE OF TARGET AIRPLANE (ASA_H)	2 DEG
5. ASA IN PLANE PERPENDICULAR TO WING PLANE OF TARGET AIRPLANE (ASA_V)	2 DEG
6. AIRPLANE DIVE OR CLIMB ANGLE (D/CA)	2 DEG
7. AIRPLANE ANGLES OF ATTACK (AOA) AND SIDESLIP ANGLES (ASS)	2 DEG
8. RATE OF CHANGE OF AOA	2 DEG/SEC
9. AIRPLANE NORMAL ACCELERATION (N)	0.5 "G"
10. ANTENNA TRAIN ANGLE (ATA)	2 DEG
11. ATA IN WING PLANE OF FIGHTER AIRPLANE (ATA_H)	2 DEG
12. ATA IN PLANE PERPENDICULAR TO WING PLANE OF FIGHTER AIRPLANE (ATA_V)	2 DEG
13. AIRCRAFT POSITION COMPONENTS IN RESPECT TO EARTH COORDINATES (x, y, z) z SHALL BE ABOVE MEAN SEA LEVEL	25 FT
14. RATE OF CHANGE OF z, RATE OF CLIMB (RC)	FT/MIN/100
15. AIRPLANE CALIBRATED AIR SPEED (CAS)	10 KNOTS
16. AIRPLANE TRUE AIR SPEED (TAS)	15 KNOTS
17. AIRPLANE MACH NUMBER (M)	0.02 M
18. AIRPLANE ATTITUDE WITH RESPECT TO EARTH COORDINATES	2 DEG
19. AIRPLANE VELOCITY COMPONENTS x, y, AND z	15 FT/SEC
20. RATE OF N	0.5 "G"/SEC

NOTES:

1. THE ABOVE STANDARD DEVIATIONS SHALL NOT BE EXCEEDED FOR AIRPLANE AIRSPEEDS BETWEEN 250 FT/SEC. A GRACEFUL DEGRADATION IN ACCURACY IS ACCEPTABLE FOR AIRSPEEDS BELOW 250 FT/SEC.
2. PARAMETERS HAVING MATHEMATICAL SINGULARITIES MAY DEGRADE GRACEFULLY AROUND THE SINGULARITIES.

FIGURE 6.2-3 REQUIRED ACCURACIES OF THE ACMI MEASUREMENT SYSTEM RELATING TO THE MEASUREMENT OF THE AIRCRAFT POSITION IN SPACE

9-1086

ACCELERATION	-2.5 TO 8.5 "G"
AIR SPEED	100 FT/SEC TO 1.6 MACH
ROLL RATE	0 DEG/SEC TO 360 DEG/SEC
RELATIVE VELOCITY	0 FT/SEC TO +4000 FT/SEC
MINIMUM MISSILE FIRING RANGE	1000 FT
MAXIMUM MISSILE FIRING RANGE	30,000 FT
AIRPLANE ATTITUDES	ALL
AIRPLANE ALTITUDES	5000 FT TO 40,000 FT

FIGURE 6.2-4 THIS FIGURE INDICATES THE AIRCRAFT DYNAMIC RANGE WITHIN WHICH THE MEASURES LISTED IN FIGURE 6.2-3 WILL OPERATE

9-1087

SUBSYSTEM OR FUNCTION	AIR COMBAT MANEUVERING RANGE - YUMA, AZ.	AIR COMBAT MANEUVERING INSTRUMENTATION - NELLIS AFB NEV.
RANGE SIZE	30 MILE CYLINDER 5,000 TO 40,000 MIN/MAX ALTITUDE	30 MILE CYLINDER 5,000 TO 40,000 MIN/MAX ALTITUDE
AIRCRAFT CAPACITY	4 FAST 12 SLOW	8 FAST 12 SLOW
RADAR TRACKING STATIONS	5	7
AIRCRAFT INSTRUMENTATION SUBSYSTEM	AIM-9 POD 64 BIT TRANSMISSION	AIM-9 POD 96 BIT TRANSMISSION INCREASED WEAPONS SYSTEMS USAGE REPORTING CAPABILITY
TRACKING INSTRUMENTATION SUBSYSTEM	DATA RATE FOR 64 BIT TRANSMISSION	ENLARGED CAPACITY TO TRANSMIT NEW DATA RATE
CONTROL AND COMMUNICATION SUBSYSTEM	NO PROBABILITY OF KILL. MANUAL PAIRING BY RANGE TRAINING OFFICERS. 3 SIGMA-9 COMPUTER PROCESSING UNITS.	PROBABILITY OF KILL (P_K) DATA. STORED MISSILE RELIABILITY USED TO CALCULATE P_K. NEAREST AIRCRAFT LINE OF SIGHT WEAPONS PAIRING. GENERATES EXPANDED REASONS FOR MISS DIAGNOSTIC MESSAGES. EXPANDED COMPUTER CAPABILITY. 6 SIGMA-9 COMPUTER PROCESSING UNITS.
DISPLAY AND DEBRIEFING SUBSYSTEM	ONE AT YUMA ONE AT MIRAMAR	TWO AT NELLIS - IMPROVED RETRIEVAL AND PLAYBACK SYSTEM - FOUR FOOT SQUARE FOUR COLOR BRIEFING DISPLAY. INCREASED CAPACITY DISPLAY FOR MISSION PARAMETER INCLUDES GUNS, UP TO EIGHT MISSILES AT A TIME.

FIGURE 6.2-5 THIS FIGURE LISTS THE DIFFERENCES BETWEEN THE ACMR AND ACMI FACILITIES AS THEY ARE CURRENTLY CONFIGURED

drawback to the ACMR/I concept was the one most frequently mentioned by the fighter pilots answering our questionnaire.[23] The ACMR/I must, therefore, be considered as a tool to measure the necessary conditions for becoming a fighter pilot - the what to do and how to do it aspects of air-to-air combat. The question of whether a man will fight must be determined by other techniques.[24]

9-1089

QUESTION: "WHAT DO YOU THINK ARE THE PRINCIPAL BENEFITS AND LIMITATIONS OF ACMR TRAINING?"

RESPONSES REGARDING ACMR/I BENEFITS:

MORE REALISTIC THAN MOST PEACETIME TRAINING – CHALLENGES THINKING AND SKILL. THE ONLY MISSING INGREDIENT IS LIVE AMMO OVER ENEMY TERRITORY.

THE LIMITATIONS SHOULD NOT BE DECISIVE. SOME CANNOT PERFORM THEIR BEST UNTIL IT IS THE ACTUAL THING. I REPEAT AGAIN – IT IS THE INDIVIDUAL WHO HAS THE HEART, DESIRE AND WILL-TO-DO.

EXPOSES PILOTS TO NEED FOR DETERMINATION, ALERTNESS AND QUICK REACTION TO A SITUATION – THE SITUATION IS ARTIFICIAL, BUT THE BEST PRESENTATION AVAILABLE – PILOTS MUST TAKE ADVANTAGE OF THE BENEFITS, AND ACCEPT THE LIMITATIONS. PUT REALISM INTO THE SCENARIOS.

IT TEACHES A PILOT HOW TO MANEUVER HIS AIRCRAFT INTO POSITION TO KILL. IT ALSO GIVES A PILOT THE REAL FEEL OF HIS AIRCRAFT AND HOW IT HANDLES. THE LIMITATIONS ARE THAT REAL BULLETS ARE NOT BEING FIRED. SOME PILOTS ARE GOOD IN ACM, BUT THEY CANNOT FACE THE REAL THING.

THE SAME LIMITATIONS AS ANY TRAINING. "IF YOU LOSE YOUR LIFE IS NOT AT STAKE."

IMPROVE INDIVIDUAL SKILLS, LEARN EQUIPMENT LIMITATIONS, ETC. UNFORTUNATELY, A PILOT 'S ABILITY AND AGGRESSIVENESS VARIES CONSIDERABLY WHEN HE IS BEING SHOT AT, AND ACMR IS ONLY OF LIMITED EFFECTIVENESS IN DETERMINING THIS GOVERNING CHARACTERISTIC.

FIGURE 6.2-6 RESPONSES TO QUESTION ON THE BENEFITS OF ACMR/I TRAINING. OF THE 300 PILOTS WHO RESPONDED TO THIS QUESTION, 98% INDICATED THERE WOULD BE SOME BENEFITS FROM ACMR/I TRAINING

A number of other constraints, beside the lack of enemy fire and the resultant emotional response, are present in the ACMR/I.[25] These constraints are a function of the artificial characteristics of the test environment and limitations in equipment and software capabilities. A list of specific range limitations, their cause, and the effects they have on air combat realism is detailed in Figure 6.2-7.

Despite these drawbacks, the ACMI provides a unique facility for the documentation and evaluation of both aircraft and pilot capabilities for air-to-air combat.

9-1088

RANGE CONSTRAINT	REASON FOR CONSTRAINT	RESULTANT LIMITATIONS WITH RESPECT TO "REAL" AIR COMBAT
MANEUVERING BOUNDARIES	SIZE OF FACILITY	LIMITED COMBAT AREA
MINIMUM ALTITUDE AND OPERATION LIMITS	SAFETY	UNREALISTIC CONSTRAINTS TO ALLOWABLE COMBAT MOVEMENTS
LIMITS ON AIRCRAFT MANEUVERS, I.E., OVER "G"	SAFETY	LIMITS MANEUVERS WHICH MAY BE EXECUTED
MISSILE AND GUN FIRE SIMULATED	NO ACTUAL WEAPONS CAN BE LAUNCHED	FEW CUES FOR EITHER ATTACKING OR DEFENSIVE AIRCRAFT CONCERNING WEAPONS FIRING. (ATTACK AIRCRAFT DOES HAVE SUCCESSFUL MISSILE LAUNCH INDICATOR)
RANGE SPECIFIC SCENARIO	SPECIFIC AREA, ENEMY AIRCRAFT, NO GROUND FIRE, VISUAL IDENTIFICATION RULES	AIR COMBAT SCENARIO BECOMES SPECIFIC TO A REAL, BUT LIMITED, COMBAT ENVIRONMENT
GUN HIT SIMULATION BASED ON STATISTICAL ANALYSIS OF AIMING ERROR AND PROBABILISTIC DISTRIBUTION OF GUN ROUNDS	INSTRUMENTATION LACKS ACCURACY TO MEASURE BULLET HITS ON OPPONENT	NO "TRUE" ESTIMATES OF GUNFIRE HITS
PROBABILITY OF KILL DATA BASED ON F-4E, NOT F-15 OR F-14	FUNDING LIMITATIONS PROHIBITED DEVELOPING PROPER PROBABILITY OF KILL DATA	APPROXIMATIONS FOR ALL PROBABILITY ESTIMATES

FIGURE 6.2-7 LISTING OF MAJOR CONSTRAINTS OF THE ACMI AS CONFIGURED FOR ACEVAL-AIMVAL AND THEIR EFFECT ON THE REALISM OF THE AIR COMBAT ENCOUNTER

[23] The following quote is an illustrative sample of the responses:
"Some pilots are good in ACM, but then cannot face the real thing."
"I think it's great training - but when the guy's life is at stake - will he still perform as well? It's like putting all your money on a movie character in an actual street fight."

[24] This is best summed up by another quote from our pilot sample, "It (the ACMR/I) measures the Head and Hands accurately, but (you) cannot measure Heart except under actual combat conditions."

[25] This discussion will center on the ACMI as it is configured for the ACEVAL-AIMVAL tests. This configuration is the "best" system of its kind currently operational.

6.2.4 Performance Evaluation on the ACMR/I - The ACMR/I was constructed primarily as a training facility for air-to-air combat. As such, instructor pilots reviewed each combat engagement with the students during post-mission debriefing sessions. The purpose of this review was to evaluate performance during a mission and to identify and analyze tactical errors. Data on kills, misses and kill/loss ratios were evaluated, but the emphasis was on analysis of tactical errors and the definition of "best" maneuvers.

6.2.4.1 Time-Variant Figure-of-Merit as a Measure of Air-to-Air Combat Performance - In an effort to define an objective measure of pilot performance, the Naval Air Test Center at Patuxent River, MD, the Naval Weapons Center at China Lake, CA, and the Center for Naval Analysis in Washington, D.C., have cooperated to develop a time-based figure-of-merit as a measure of performance in the ACMR/I (Simpson, 1976). This technique is based on continuously calculating a figure-of-merit or performance index at each point in the engagement. This performance index uses the aircraft parameters typically measured in the ACMR/I (see Figure 6.2-8) and is indicative of the relative advantage/disadvantage at a particular time in the engagement. The index is derived from an examination of the inter-airplane angular geometry, distance and dynamics, and an evaluation of the weapons systems envelope. It takes the form of:[26]

$$PI = DA_N(1-F_r)K \text{ where}$$

PI = performance index

DA_N = the normalized angular geometry resulting from the combination of the Angle Off Tail and the Antenna Train Angle (See Figure 6.2-8).

F_r = a penalty derived from the range between aircraft and effective gun or missile range.

K = a mathematical function describing a positive or negative weighting function for closing rate, dependent on the weapons delivery envelope (both guns and missiles).

Overall, the highest value of the index would occur when the attacker was directly on the tail of the opponent, within missile or gun range, and at zero closing velocity. In a like manner, the worst case, a high negative value, would occur when the situation was reversed. The index is valuable in that it provides both a summary and a time history plot of the relative positional advantage of the aircraft.

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PARAMETER	DEFINITION
AIRPLANE PARAMETERS	
ANGLE OF ATTACK (AOA)	ANGLE BETWEEN THE FREE STREAM FLOW AND THE AIRPLANE REFERENCE LINE
NORMAL ACCELERATION (N_z)	THE LOAD FACTOR TAKEN PERPENDICULAR TO THE FLIGHT PATH
ALTITUDE (ALT)	GEOMETRIC ALTITUDE ABOVE GROUND LEVEL
INDICATED AIRSPEED (IAS)	AIRSPEED MEASURED BY AIS UNCORRECTED FOR POSITION ERROR
SPECIFIC ENERGY (E_S)	SUM OF THE WEIGHT SPECIFIC KINETIC AND POTENTIAL ENERGIES
TARGET MACH NUMBER (MT)	MACH NUMBER OF THE TARGET AIRPLANE
INTER-AIRPLANE PARAMETERS	
RANGE (R)	LINE OF SIGHT DISTANCE BETWEEN THE CENTER OF GRAVITY OF TWO AIRPLANES
CLOSING VELOCITY (VC)	TIME RATE OF CHANGE OF RANGE
ANTENNA TRAIN ANGLE (ATA)	THE ANGLE BETWEEN THE AIRCRAFT REFERENCE LINE FORWARD OF THE CENTER OF GRAVITY AND ANY SIGHT LINE
ANGLE OFF TAIL (AOT)	THE ANGLE BETWEEN THE AIRCRAFT REFERENCE LINE AFT OF THE CENTER OF GRAVITY AND ANY SIGHT LINE

FIGURE 6.2-8 PRIMARY AIR COMBAT MANEUVERING PARAMETERS. THESE MEASURES INDICATE THE STATE OF AN AIRCRAFT AND THE INTERACTIVE SPATIAL RELATION BETWEEN THE OPPONENT AIRCRAFT

[26] A complete description of the performance index and the equations used to derive the values of DA_N, F_r, and K can be found in Simpson (1976).

As a performance measure, the index has a strong relationship to the AMLS measure developed by the NASA simulation group. The AMLS represents the sum of 12 simple binary decisions concerning the state of the two opponent aircraft and uses parameters which are very similar to those used in the performance index. While the AMLS is typically treated as a summary measure, it is possible to generate the same type of engagement time history as found with the performance index. The major difference between the two is the use of complex equations relating to inter-airplane spatial relationships in computing the performance indices. Both techniques provide potentially valuable scoring criteria for pilot performance, but neither technique has been thoroughly validated against more traditional evaluation criteria such as kills or time-in-envelope. Data from ACEVAL-AIMVAL should provide the kind of data base necessary to validate both concepts.

6.2.4.2 ACEVAL-AIMVAL Pilot Performance Criteria Definition - ACEVAL-AIMVAL had as its objectives the evaluation of the effects of force mix (the number of aircraft on each side) and the operational utility of existing and proposed short range, air-to-air missiles. To accomplish this evaluation, performance criteria have shifted from a subjective analysis of the missions to mission success criteria such as number of kills and kill/loss ratios. These kinds of objective criteria are necessary for an unbiased evaluation of the mission parameters under investigation. The ACEVAL-AIMVAL Test Plan (ACEVAL-AIMVAL TEST PLAN, Vol. II and III, 1976) details a comprehensive analysis of both test and control variables with respect to weapons-oriented dependent variables. A list of the primary variables is given in Figure 6.2-9. These measures are used to derive secondary measures of effectiveness such as percent kills versus firings and firings versus opportunities. They are also used to generate descriptive and probability of success measures, given various mission factors. These measures (hits as a function of angle off boresight, firings as a function of first sightings, time to fire given visual ID) serve as a means of evaluating tactics and missile effectiveness to generate an optimum engagement profile. If executed as planned, the data descriptions generated from ACEVAL-AIMVAL will provide invaluable documentation on what makes a successful encounter.

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RADAR DETECTION RANGE
VISUAL DETECTION RANGE
VISUAL IDENTIFICATION RANGE
NUMBER OF RADAR MISSILE FIRINGS
NUMBER OF INFRA-RED MISSILE FIRINGS
NUMBER OF GUN FIRINGS
TOTAL NUMBER OF FIRINGS
NUMBER OF RADAR MISSILE KILLS
NUMBER OF INFRA-RED MISSILE KILLS
NUMBER OF GUN KILLS
TOTAL NUMBER OF KILLS
LOSS RATE
POSITION – TARGET ANGLE OFF BORESIGHT AT FIRING
ASPECT OF TARGET WHEN FIRING
RANGE TO TARGET AT FIRING
TIME INTO MISSION AT FIRING

FIGURE 6.2-9 LIST OF PRIMARY DEPENDENT VARIABLES USED IN ACEVAL-AIMVAL TO EVALUATE AIRCRAFT PERFORMANCE AND NEW MISSILE CONCEPTS

This plan also includes a multiple regression analysis of the data. This technique can be used to identify non-overlapping factors which determine mission success. Thus, the analysis may find that first visual detection, range to target, shots taken, and angle off are all independent contributors to weapon kills. Data of this type are critical for the definition of both selection and training programs. Having identified critical skills in an operational manner, selection programs can be tailored to evaluate candidates with respect to the abilities required to master these skills. Where skills can be acquired or refined, training packages can be designed to improve pilot capability. As a case in point, let us consider first visual detection as a critical skill. Pilot opinion rates seeing-the-enemy-first as a highly important part of winning in the air combat theater. This capability is made up of both innate and trainable characteristics. Visual acuity, or more precisely, the ability to detect slight movement or glints, especially in the periphery of the visual field, is one aspect of the ability. This must be coupled with good central acuity to determine, at maximum

range, whether the detected object is a friendly aircraft, or a target. Additional factors such as consistent search for the enemy are also important to detection.[27] Based on these data, selection tests could be devised to measure a candidate's capability for peripheral target search and detection. This same characteristic also has potential for improvement through training. A study by Low (1946) indicates that training can increase peripheral acuity by as much as 300%.

This specific set of selection and training implications of the ACEVAL-AIMVAL data analysis is, of course, only illustrative of the kind of data applications which can be made. Most importantly, while the study is concerned with weapons system effectiveness, the analysis should yield an empirically derived, nonoverlapping set of criteria on which to evaluate pilot effectiveness. For this reason, careful attention should be paid to the ACEVAL-AIMVAL results as both a testbed to evaluate other approaches to the measurement of pilot capability and as a source of validated, objective measures of pilot performance.

6.3 SUMMARY AND COMMENTS

This review of air-to-air combat simulators reveals that they have broad capabilities and applications. They have been used primarily for training and as design tools. As such, the available data cannot readily be manipulated to yield the human performance reliability measures which are needed for assessing differences in pilot capability. Despite this, we have, for a limited set of simulations, extracted data suggesting the potential utility of these devices in the selection domain. Potential human performance criterion measures including theoretical hits, time in gun (or missile) envelope, and probability of a kill have been identified. Studies designed to provide performance reliability data are needed to further substantiate the potential of the various criterion measures.

Data from mock combat engagements on the highly instrumented combat maneuvering ranges (both ACMR and ACMI) reveal that these devices can be used for intermediate validation of pilot selection devices. The ACEVAL-AIMVAL program demonstrates that these ranges can be used for applications beyond training. As with the simulators, there is a great need for human performance reliability data from the combat maneuvering ranges which would be invaluable for refining criterion measurement for selection purposes.

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[27] In response to the question, "What lessons did you learn during your first combat engagement?" Our pilot sample stressed constant search of the sky for the enemy. Typical responses were as follows:

"He who sees the other man first has the overwhelming advantage."
"Always keep looking for far-away enemy aircraft - see them first with eyeball or radar."
"Look around, look around, look around!"
"The one you don't see is the one that will get you."
"Eye sight covering 360°."

7.0 ASSESSMENT OF THE COST EFFECTIVENESS OF VARIOUS SELECTION TEST INSTRUMENTS AND THE RECOMMENDED AIR COMBAT EFFECTIVENESS STUDY (ACES) PROGRAM

Section 4 identified the characteristics and critical skills making up our profile of the combat effective pilot. This profile will be reviewed on an item-by-item basis to select the most cost-effective test instrument for obtaining measures to be used as selection criteria. The breakdown of preliminary selection characteristics by testing techniques will be summarized and used to define a recommended air combat effectiveness study (ACES) program. The ACES program will consist of two parts, a peacetime preliminary validation, and a combat contingency validation plan. The peacetime validation plan will be dependent upon a selection test program using, as an intermediate criterion, pilot performance on the air combat maneuvering ranges. This approach makes use of a peacetime combat surrogate which has a high degree of acceptance among experienced combat pilots (see Section 6.2). The use of the air combat maneuvering ranges allows the validation and refinement of the selection program without the necessity of engaging in a major aerial war. The results would yield a comprehensive and cohesive pilot selection battery which could readily be validated during a major aerial conflict. An overview of the process which led to the ACES program is shown in Figure 7.0-1.

The combat contingency validation plan outlines the procedures for validating the selection tests against the ultimate criterion, performance during combat. To take maximum advantage of this, it is necessary to have prepared a comprehensive data gathering plan. We fully recognize the fact that the exigencies of combat prohibit many of the niceties of experimentation which might be desirable, but history has demonstrated that adequate data recording can be accomplished within the combat arena. This can only be done, however, when data specifications and conditions have been carefully defined. The plan must be waiting in a standby mode for the occurrence of a major aerial conflict.

7.1 ASSESSMENT OF THE COST EFFECTIVENESS OF VARIOUS SELECTION TEST INSTRUMENTS

In Section 4, 12 major pilot selection domains were reviewed and factors within each domain were evaluated for inclusion in our preliminary profile of the combat effective pilot. This section reviews the recommended selection factors within the 12 domains and evaluates the appropriateness of a number of test instruments for use in assessing these factors. This evaluation was based upon four criteria: (1) cost of application; (2) ease of administration and impact on the present selection program; (3) objectiveness of scores; and, when available, (4) historical validity of such test instruments as a means of measuring that particular selection factor. Cost of application includes the cost of test development and setup and the cost of administering the tests to the candidates. Ease of administration and impact of the tests on the existing programs are functions of the number of students which can be run at a given time, the total amount of student and instructor time required to administer and score the tests, and whether or not the use of any type of remote facility is necessary to implement the tests. Objectiveness of scores is related to whether the scoring procedure on the test is totally objective or requires some subjective estimates of the candidates' capabilities. Historical validity refers to the degree of relationship between predictors, as measured by various test devices (techniques), and criteria of combat effectiveness reported in prior research. The first two criteria (cost, and ease of administration and impact) tended to drive our decision toward the simplest test available for assessing that factor; whereas the last two criteria, objectiveness of scores and historical validity, tended to drive our decision toward the best test available, regardless of cost, ease of administration, or impact.

7.1.1 General Discussion of Selection Tools - Their Strengths and Weaknesses - We have identified seven test methodologies as means of assessing the characteristics and critical skills outlined in Section 4. These are paper-and-pencil tests, structured

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SCIENTIFIC STUDIES OF COMBAT INFANTRY

U.S. MILITARY AVIATION SELECTION RESEARCH

FOREIGN AVIATION SELECTION PROGRAMS

INPUTS FROM AMERICAN AVIATORS AND ACES

INTEGRATED PROFILE OF THE COMBAT EFFECTIVE FIGHTER PILOT	ADEQUATELY TESTED BY USAF	NOT ADEQUATELY TESTED BY USAF	PAPER & PENCIL SELECTION TESTS	SMALL APPARATUS AND COMBAT JOB SAMPLE TESTS	SITUATIONAL TESTS AND RATINGS
MEDICAL/PHYSIOLOGICAL					
• GOOD PHYSICAL HEALTH	√				
• ABILITY TO WITHSTAND PHYSIOLOGICAL STRESS		√		√	
APTITUDE					
• PILOT COMPOSITES		√	√		
• NON-PILOT COMPOSITES (e.g. NAVIGATOR)	√				
• GENERAL APTITUDE (INTELLIGENCE)	√				
• NUMERICAL SKILLS	√				
• VERBAL SKILLS	√				
• MECHANICAL SKILLS	√				
• FLIGHT APTITUDE (GENERAL AND COMBAT)		√		√	
DECISION MAKING/INFORMATION PROCESSING					
• SELECTIVE ATTENTION		√		√	
• DECISION TIME		√		√	
• QUALITY OF COMBAT DECISIONS		√			
• ALERTNESS		√		√	
• INTEGRATIVE DECISIONS		√		√	
SENSORY-MOTOR ABILITIES					
• VISUAL PERCEPTION		√		√	
• MOTOR COORDINATION		√		√	
• SPATIAL ORIENTATION		√		√	
• SPATIAL–PERCEPTUAL ABILITY		√		√	
• PERCEPTUAL SPEED		√		√	
AVIATOR SKILLS, KNOWLEDGES, AND TASKS					
• EQUIPMENT KNOWLEDGE		√	√		
• FLIGHT SKILLS		√			
• INSTRUMENT READING		√		√	
• AERIAL GUNNERY		√		√	
PERSONALITY					
• AGGRESSIVENESS		√			√
• SELF CONFIDENCE		√			√
• MENTAL HEALTH	√				
• PERSONALITY STYLE		√	√		
• COURAGE		√			√
PERSONALITY – LEADERSHIP					
• RESPONSIBILITY FOR MEN IN COMBAT		√			√
• PHYSICAL AND COMBAT LEADERSHIP		√			√
MOTIVATION					
• DETERMINATION/DESIRE		√			√
• SELF DISCIPLINE		√			√
• SATISFACTION		√		√	
REACTIONS TO STRESS					
• PERFORMANCE UNDER STRESS		√			√
• EMOTIONAL CONTROL		√			√
• ABILITY TO WITHSTAND PSYCHOLOGICAL STRESS		√			√
• ANXIETY TOLERANCE		√			√
RISK TAKING					
• WILLINGNESS TO TAKE CALCULATED RISKS		√			√
SOCIAL FACTORS					
• TEAMWORK		√			√
• SOCIABILITY		√			√
• INTERPERSONAL RATING		√			√
BIOGRAPHICAL DATA					
• LIFE INVENTORY		√	√		
• ACADEMIC HISTORY	√				
• MILITARY HISTORY	√				
• MILITARY RANK	√				

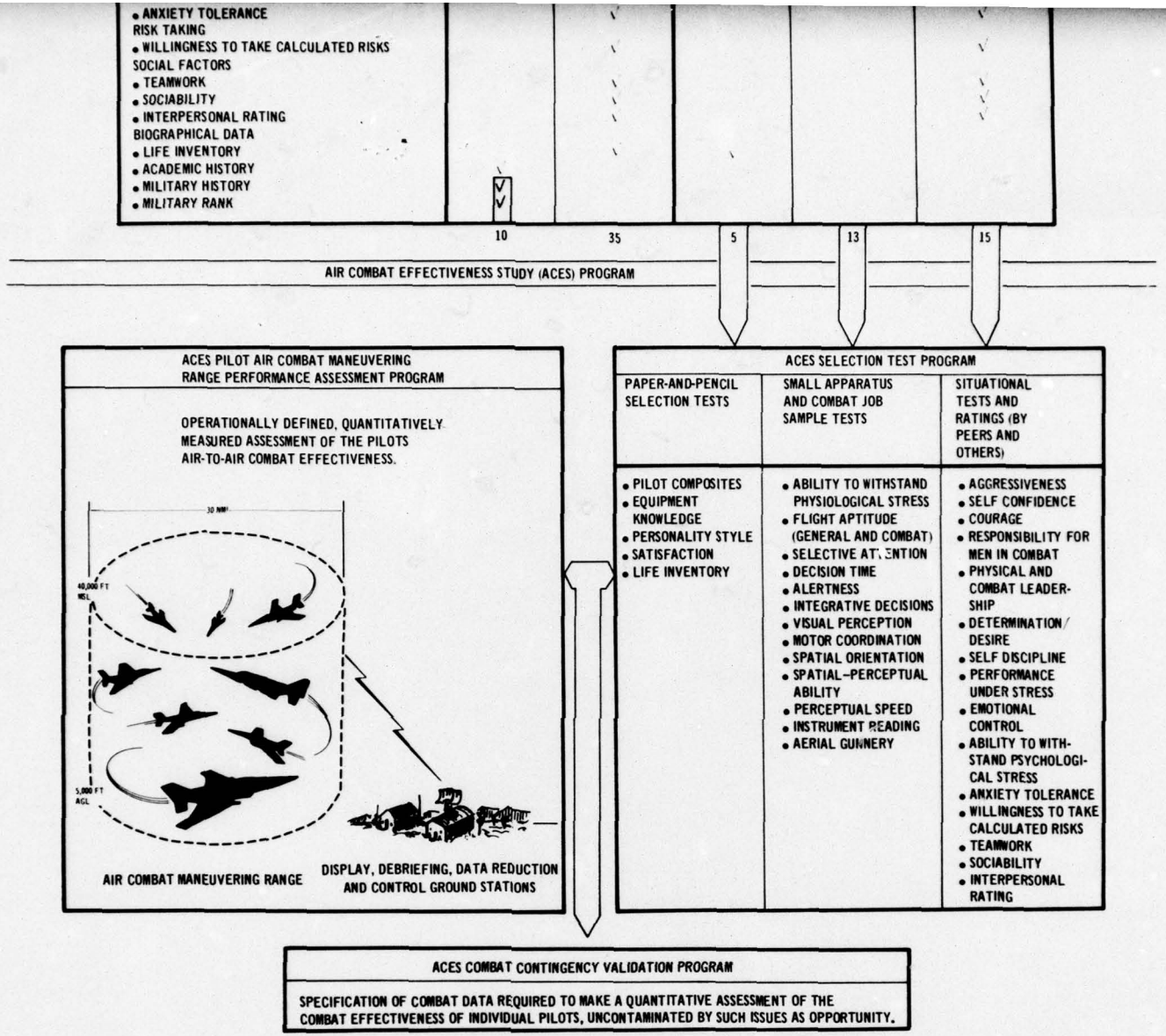


FIGURE 7.0-1 OVERVIEW OF ARPA FUNDED STUDY AND RECOMMENDED AIR COMBAT EFFECTIVENESS STUDY (ACES) PROGRAM.

interviews, peer and instructor ratings, situational tests, small apparatus tests, large facility tests, and job sample tests. Each of these test methodologies is discussed below.

7.1.1.1 Paper-and-Pencil Tests - Paper-and-pencil tests can be administered as group tests, and, depending upon the questions asked, can yield either subjective or objective responses. Objective responses can be obtained using such measures as number correct and category of response. Subjective responses such as estimates of a candidate's capabilities and present attitudes can also be obtained. These instruments have an extremely low cost once the test has been developed. They should have a very minor impact on existing programs as they can be inserted into programs at the expense of an hour or two of time per candidate. Since this time would be spent in a group activity, the cost of the instructor time would also be minimal. Specific paper-and-pencil test items would have to be generated for each selection factor tested. Once this is accomplished, additional costs for this type of test are extremely low.

7.1.1.2 Interviews - In general, interviews tend to sample some of the same types of characteristics measured by paper-and-pencil tests. They are dependent upon a one-to-one relationship between the candidate and the interviewer. A standardized interview form is preferred since it gives structure to the interview and insures that all of the relevant questions are asked. The measures obtained are primarily subjective since they relate to the interviewer's impressions of the candidate's responses. Tape recordings of the interviews can be obtained for a more objective analysis, but, since they occur in real time, the analysis of these records is very time-consuming and costly. The objectivity of the interviewee's responses is to a great extent dependent upon the interviewer's training and skills. Between-interviewer reliability can be moderately high providing the interviewers are properly trained. Because of the nature of the interview situation, the cost per candidate for this technique would be quite high. The impact on the existing program can be minimized by inserting candidate interviews into the program on an individual-by-individual basis over a period of time. Due to the basically subjective nature of the interview and the fact that, in our opinion, it does not add a significant amount of unique data unobtainable by paper-and-pencil tests or other means, we feel that the interview is not appropriate for inclusion in the selection battery.

7.1.1.3 Ratings - There are two types of ratings under consideration: ratings by the candidate's fellows on traits or capabilities (peer ratings); and ratings by specially trained pilot instructors on traits or the candidate's competence in performance of tasks assigned during instruction (instructor ratings). One of the major drawbacks of ratings is that they are essentially subjective in nature. Each individual is rated by another on the basis of a number of undefined variables. Thus, it is possible that a candidate can be given a high rating as a function of his popularity rather than his capability. Despite this subjectivity, peer ratings have exhibited rather high correlations with combat effectiveness. Both peer ratings and ratings by instructors and trained observers have been used successfully by the Israelis. Additionally, the cost per candidate for instituting these kinds of ratings would be relatively low, approximately the same as the cost of inserting paper-and-pencil tests into the curriculum. Each student would be called upon to rate his peers on a number of selection factors which have been identified. Pilot instructor ratings would be obtained in much the same way with the addition of ratings on competence in various pilot functions as well as personal characteristics. Therefore, in view of the relatively low cost and the empirical validity of ratings, they are recommended for inclusion in the selection battery.

7.1.1.4 Situational Tests - Situational tests assess behavior by using controlled environments which parallel those which would be encountered on the job. They have many of the characteristics of a job sample (e.g., stress), but they are designed

to evaluate emotional, social, attitudinal and other personality variables. The Air Force currently has a number of programs which could be considered situational tests should the measurements and observational criteria be applied to behaviors generated in and by the situations. Specifically, these are the escape and evasion school and the survival school, both of which are requirements for Air Force pilots. These programs are meant to be training environments with the candidate pilot learning skills necessary for survival and evasion of would-be captors, and successful maintenance of the military codes should he be taken prisoner. The Israelis currently use a situational testing environment where candidates are gathered for a rigorous program of selection testing prior to their full acceptance into the pilot program. While this type of test is quite expensive to set up, the overall cost may not be prohibitive on a cost per student basis because it is essentially a group testing procedure. In addition, unlike paper-and-pencil tests, situational tests would not have to be generated for each selection factor specified in our selection profile, since a given situational test could provide information on a number of these factors. This type of test has the advantage of allowing the observer and the peer group to assess, in a stressful environment, many personality factors which might be sampled by paper-and pencil tests under more relaxed conditions. The real combat setting is, of course, very stressful, and the more the testing conditions approximate that combat reality, the more valid the measures obtained will be. Implementation of situational testing would have a fairly high impact on existing programs. The normal sequential order of training would have to be broken and a survival school-like procedure would have to be instituted while the candidates are still competing for the available slots in the pilot training program. Despite this, their value for assessing selection factors which cannot be measured by other types of tests justifies the inclusion of situational tests in the selection program.

7.1.1.5 Small Apparatus Tests - Small apparatus tests refer to those tests which are dependent upon a relatively simple piece of equipment. These tests can be operated by a single instructor and should be highly reliable and relatively inexpensive. In some cases, a single test can be used to measure more than one ability, but the test itself should be chosen and developed with a specific selection factor in mind. These apparatus tests can range from something as simple as a choice reaction device to something as complex as a dynamic peripheral vision test. The latter device would test the candidate's capability to detect moving targets in the visual periphery while concentrating on a difficult primary task.

These tests can be administered on a group basis and yield objective performance measures. Once the basic apparatus is in place, the cost per student is fairly low. The impact on the existing program in terms of time cost would be relatively low, i.e., less than 1/2 hour per student per test. It is possible that a group of these tests could be given in sequence in a one or two day period within some type of specially constructed testing facility. The small apparatus test represents a very effective way of assessing a number of perceptual, motor, and judgmental selection factors.

7.1.1.6 Major Facility Tests - These tests are essentially an extension of the small apparatus tests, but they are generally far more expensive, often requiring substantial facilities and large staffs, including technicians to maintain them and other auxiliary personnel for instructional and safety reasons. Two examples of large facility tests would be the centrifuge and the altitude test chamber. These test apparatuses essentially duplicate severe environments in which the pilot must perform during combat. They offer a unique opportunity to evaluate performance under environmental stress. Such large facility tests are expensive to operate and generally are remotely located from major pilot selection and training centers. The utilization of such tests would obviously have a

significant impact on existing programs, requiring large amounts of time and money to maintain them as well as taking up a significant amount of time per candidate. On the positive side, they are capable of producing objective performance measures of students' reactions to psychological and/or physiological stress. The capability to withstand this type of stress is an attribute which pilots have rated as very important for becoming an effective combat aviator. Because of the cost involved with the major facility tests, they are not recommended for use at the candidate level. However, they do offer an opportunity for significant refinement in the selection procedures should they be applied as part of a secondary selection program for pilot training graduates or undergraduates.

7.1.1.7 Job Sample Tests - Job sample tests require performance of components of the piloting task. Excellent job sample situations for selecting fighter pilots would be major air combat maneuvering simulators such as the one at NASA, Langley or McDonnell Douglas, St. Louis. In these facilities, pilots are able to fly simulated combat engagements against each other in a realistic environment. These facilities have been extensively discussed in Section 6.1. For specific elements of the air combat procedure, other job sample tests or facilities can be constructed. It is possible that a relatively small and economical air combat maneuvering job sample device could be designed which would allow pilots to engage in air combat tasks within a limited budget program. The data we have generated to date indicate that the major simulators have proven to not only discriminate between pilots along a dimension of air combat capability, but function as useful training devices.

Measures on the job sample type tests can be objective or subjective. Objective measures of kills, time in gun envelope, and mean performance measures, such as the AML used by NASA, Langley, can be generated directly from the central computer controlling the simulator. Subjective estimates of how well the mission was actually flown are typically obtained from instructor pilots reviewing mission tapes during the debriefing sessions. Cost per student would be fairly high and the tests would probably have to come sometime after admission into the first phase of pilot training. Both of these factors would have significant impact on the existing programs. However, current Air Force policy appears to include the utilization of fairly complex simulators for undergraduate pilot training. We specifically refer to the Simulator for Air-to-Air Combat located at Luke Air Force Base which was discussed in Section 6.1. This device has the capability to be used as a selection tool and would have less of an impact on an existing program of pilot training than constructing some specialized large job sample facility elsewhere. Overall, the job sample approach has many similarities to the situational testing approach. Both provide information about general performance level. Job sample tests measure skill level, whereas the situational tests assess willingness to perform. The job sample approach represents one of the most integrated tasks, yielding information on a number of specific aptitide skill factors as well as having implications for personal characteristics such as aggressiveness, risk taking, and determination. It provides a high degree of realism when considering the actual task of air combat.

7.1.2 An Assessment of the Cost Effectiveness of Seven Types of Selection Instruments for Testing Each of the Factors within the Twelve Selection Domains - The seven selection test instruments described in Section 7.1.1 were evaluated as methodologies for assessing each of the selection factors within the 12 domains, and the most cost effective method for testing each selection factor was identified. The results of this analysis are shown in Figure 7.1-1.[1] This figure integrates the recommendations concerning which selection factors should be investigated further (see Section 4), with recommendations regarding the best testing methodology for each factor.

[1]This list is meant to be as exhaustive as possible, and many of the selection factors probably overlap with other factors. The final selection battery will be refined in an attempt to define a set of more distinctive factors.

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CHARACTERISTICS AND CRITICAL SKILLS	NOT RECOMMENDED FOR TESTING	RECOMMENDED FOR TESTING: ADEQUATELY TESTED BY USAF	RECOMMENDED FOR TESTING: NOT ADEQUATELY TESTED BY USAF	RECOMMENDED SELECTION TEST INSTRUMENT: PAPER-AND-PENCIL	RECOMMENDED SELECTION TEST INSTRUMENT: SMALL APPARATUS AND JOB SAMPLE	RECOMMENDED SELECTION TEST INSTRUMENT: SITUATIONAL TESTS AND RATINGS
MEDICAL/PHYSIOLOGICAL						
GOOD PHYSICAL HEALTH		X				
ENDURANCE	X					
PHYSICAL APTITUDE	X					
ABILITY TO WITHSTAND PHYSIOLOGICAL STRESS			X		X	
APTITUDE						
PILOT COMPOSITES			X	X		
NONPILOT COMPOSITES		X				
GENERAL APTITUDE (INTELLIGENCE)		X				
NUMERICAL SKILLS		X				
VERBAL SKILLS		X				
MECHANICAL SKILLS		X				
FLIGHT APTITUDE (GENERAL AND COMBAT)			X		X	
DECISION MAKING/INFORMATION PROCESSING						
SELECTIVE ATTENTION			X		X	
DECISION TIME			X		X	
QUALITY OF COMBAT DECISIONS			[X]		X	
ALERTNESS			X		X	
INTEGRATIVE DECISIONS			X		X	
SENSORY-MOTOR ABILITIES						
VISUAL PERCEPTION			X		X	
MOTOR COORDINATION			X		X	
SPATIAL ORIENTATION			X		X	
SPATIAL-PERCEPTUAL ABILITY			X		X	
PERCEPTUAL SPEED			X		X	
AVIATOR SKILLS, KNOWLEDGES, AND TASKS						
EQUIPMENT KNOWLEDGE			X	X		
FLIGHT SKILLS			[X]		X	
INSTRUMENT READING			X		X	
AERIAL GUNNERY			X		X	
PERSONALITY						
AGGRESSIVENESS			X			X
SELF CONFIDENCE			X			X
MENTAL HEALTH		X				
CONSIDERATION FOR OTHERS	X					
PERSONALITY STYLE			X	X		
COURAGE			X			X
PERSONALITY-LEADERSHIP						
RESPONSIBILITY FOR MEN IN COMBAT			X			X
PHYSICAL AND COMBAT LEADERSHIP			X			X
ADMINISTRATIVE SKILLS	X					
MILITARY BEARING	X					
MOTIVATION						
DETERMINATION/DESIRE			X			X
SELF DISCIPLINE			X			X
SATISFACTION			X	X		
REACTIONS TO STRESS						
PERFORMANCE UNDER STRESS			X			X
EMOTIONAL CONTROL			X			X
ABILITY TO WITHSTAND PSYCHOLOGICAL STRESS			X			X
ANXIETY TOLERANCE			X			X
RISK TAKING						
WILLINGNESS TO TAKE CALCULATED RISKS			X			X
SOCIAL FACTORS						
TEAMWORK			X			X
SOCIABILITY			X			X
GROUP LOYALTY	X					
INTERPERSONAL RATING			X			X
BIOGRAPHICAL DATA						
LIFE INVENTORY			X	X		
ACADEMIC HISTORY		X				
MILITARY HISTORY		[X]				
MILITARY RANK		[X]				

FIGURE 7.1-1 ANALYSIS OF CHARACTERISTICS AND CRITICAL SKILLS FOR THE PREDICTION OF THE COMBAT EFFECTIVE FIGHTER PILOT

NOTE: SHADED BOX INDICATES THIS FACTOR IS INAPPROPRIATE FOR TESTING AT THE CANDIDATE FOR PILOT TRAINING LEVEL.

The analysis indicated that two of the selection methodologies, interviews and major facility tests, were not cost effective for any of the selection factors identified. They were, therefore, dropped from the analysis. The figure also lists a number of selection factors which were not recommended for testing. In addition to these factors, four factors were revealed as being inappropriate for testing the candidate at the entry level of pilot training. Of these four, flight skills and quality of combat decisions can best be tested at the end of pilot training or advanced training by using simulators or the ACMR/I. The other two factors in this category, military rank and history, are already adequately recorded by existing Air Force procedures. These four factors were, therefore, omitted from our preliminary profile.

A review of the remaining selection factors shown in Figure 7.1-1 yielded three major testing categories: those factors which can be most effectively tested by paper-and-pencil tests, small apparatus and job sample tests, or situational tests and ratings. Small apparatus and job sample tests are recommended for testing those factors relating to the candidate's physical capabilities with respect to combat flying. Situational tests and ratings are suggested for evaluating the candidate's personal characteristics to determine whether or not he possesses the personality and motivational factors normally captured in the phrase, "will to fight." Recommendations for paper-and-pencil tests are distributed among both aptitude and personal characteristics. Section 7.2 reviews the selection factors listed under each of these testing categories and lists tests representative of those which could be used in the final program.

7.1.3 Cost Factors for the ACES Program - The analysis in Section 7.1.2 identified the types of tests which would provide the most cost effective testing program. Further delineation of the program is dependent upon budgetary considerations and the priority for the development and validation of the ACES program given by the military. The various testing procedures identified have significantly different developmental costs ranging from inexpensive, off-the-shelf paper-and-pencil tests, to special job sample simulators costing ten million dollars or more.

Analysis of these costs by testing categories indicates that different testing methodologies have different cost distributions over their various developmental and implementation phases. Costs associated with paper-and-pencil tests are most highly concentrated in the developmental phases. An example of the cost breakdown for this type of test is found in Appendix 7.A. The values given were generated for the Pilot Life Inventory Questionnaire (Short Form) developed for use as a pilot selection instrument. The cost of development for this type of test, including a preliminary validation, is approximately one hundred thousand dollars. After this initial cost, additional administration and scoring costs should be relatively small. (The best estimate of the cost of administration of these tests within the Air Force would come from existing costs records regarding the AFOQT.)

Small apparatus and job sample tests are generally more expensive than paper-and-pencil tests with a much wider range of potential costs. Simple, small apparatus tests for a number of prediction factors are already in development by Dr. Richard Pew under contract to the Air Force Human Resources Laboratory (Pew and Adams, 1975). These test apparatuses should be relatively inexpensive to construct costing between one and five thousand dollars per testing unit. Additional costs for data reduction hardware and software would increase the facility cost by several thousand dollars, however, the same control facility could be used for a number of small apparatus tests. This cost-saving consolidated facility concept could only be utilized, however, if a central testing facility were developed.

Job sample tests are significantly more expensive than small apparatus tests. They can range from three hundred and fifty thousand dollars for a specifically programmed General Aviation Trainer to over ten million dollars for an interactive air-to-air combat simulator. A cost analysis for a selection test device which would present the critical tasks of aerial gunnery is given in Appendix 7.A. This device would cost about one million six hundred and twenty-five thousand dollars for the initial unit and seven hundred and eighty-five thousand dollars for subsequent units. However, this single device would incorporate a large number of perceptual and perceptual-motor tasks which could be tested either separately or on an interactive basis, thus providing some savings on single function tests and allowing estimates of interactive processes. Another potential job sample test makes use of the General Aviation Trainer. This device has shown considerable promise as a selection instrument when validated against success in training (Long and Varney, 1975) and should be investigated for use in the ACES program. The cost of this device is about eighty-five thousand dollars for the basic simulator hardware and another two hundred sixty-five thousand dollars for peripheral equipment and software. Once again, a common central computer would significantly reduce test costs. Costing specifics of this system can also be found in Appendix 7.A.

Situational tests and ratings have relatively low set up costs; however, cost of administration on a per candidate basis, is substantial. The actual costs will be test specific and will depend on the number of candidates being tested, the complexity of the test structure, and the number of professionals necessary for proper administration of the test. To be carried out effectively, a central testing station is again recommended.

The development of a comprehensive test battery will require the integrated efforts of a number of content area experts. To expedite the program and take advantage of existing test development capabilities present in the military, industry, and the academic community, a central agency should be identified to integrate and coordinate elements of the testing program which are undertaken by specific content experts. This approach would allow for the inputs of acknowledged experts in specific topic areas. A strong central coordinating function should also be present to maintain a proper balance and control of the program. The ACES program must have a sufficient budget for the development, administration, and validation of the selection

test battery. This can only be achieved through a strong long-term commitment from the military community, to insure the support necessary for the multi-year effort required if the program is to be successful.

7.2 SUGGESTED APPROACHES TO TESTING FACTORS RECOMMENDED FOR INCLUSION IN THE AIR COMBAT EFFECTIVENESS STUDY (ACES) PROGRAM

The cost effectiveness analysis in Section 7.1 revealed three clusters of factors. These consist of factors which can be most efficiently tested with paper-and-pencil tests, small apparatus and job sample tests, and situational tests and ratings (see Figure 7.2-1). In this section, more specific initial approaches to testing the factors within each of the three clusters will be suggested.

9-1165

ACES SELECTION TEST PROGRAM		
PAPER AND PENCIL SELECTION TESTS	SMALL APPARATUS AND COMBAT JOB SAMPLE TESTS	SITUATIONAL TESTS AND RATINGS (BY PEERS AND OTHERS)
• PILOT COMPOSITES • EQUIPMENT KNOWLEDGE • PERSONALITY STYLE • SATISFACTION • LIFE INVENTORY	• ABILITY TO WITHSTAND PHYSIOLOGICAL STRESS • FLIGHT APTITUDE (GENERAL AND COMBAT) • SELECTIVE ATTENTION • DECISION TIME • ALERTNESS • INTEGRATIVE DECISIONS • VISUAL PERCEPTION • MOTOR COORDINATION • SPATIAL ORIENTATION • SPATIAL PERCEPTUAL ABILITY • PERCEPTUAL SPEED • INSTRUMENT READING • AERIAL GUNNERY	• AGGRESSIVENESS • SELF CONFIDENCE • COURAGE • RESPONSIBILITY FOR MEN IN COMBAT • PHYSICAL AND COMBAT LEADERSHIP • DETERMINATION/ DESIRE • SELF DISCIPLINE • PERFORMANCE UNDER STRESS • EMOTIONAL CONTROL • ABILITY TO WITHSTAND PSYCHOLOGICAL STRESS • ANXIETY TOLERANCE • WILLINGNESS TO TAKE CALCULATED RISKS • TEAMWORK • SOCIABILITY • INTERPERSONAL RATING

FIGURE 7.2-1 SELECTION FACTORS AND TESTING METHODOLOGIES

7.2.1 Factors to be Tested by Paper-and-Pencil Tests - Numerous paper-and-pencil tests which have been used for the selection of other military personnel and pilots, in general, could easily be adapted for the selection of combat effective fighter pilots. Furthermore, many paper-and-pencil tests which are available for other purposes can be adapted, or used in their present form for that purpose. These include both pilot composites and tests of personality style (see Figure 7.2-1). A good starting point for developing pilot composites is with the revision of the components of the AFOQT. "Personality style" and "satisfaction" can probably be assessed with a variety of existing personality testing devices.

The assessment of personality factors using paper-and-pencil tests has a long history (DuBois, 1970), and many devices are undoubtedly appropriate candidates for inclusion in our recommended fighter pilot selection program. They would, of course, have to be validated against performance in the operational environment. Egbert, Meeland, Cline, Forgy, Spickler, and Brown (1957) used the Minnesota Multiphasic Personality Inventory (MMPI), the California Psychological Inventory (CPI), and Cattell's Sixteen Personality Factor Test as part of their test battery and found these devices useful for distinguishing between fighters and non-fighters. It is not unreasonable to expect that these devices would also be useful for selecting combat effective fighter pilots. Other paper-and-pencil personality tests such as the Eysenck Personality Inventory (EPI) may be useful for distinguishing among pilots.[2]

Life inventory factors can best be assessed by some variant of our own Pilot Life Inventory Questionnaire which has been developed expressly for the purpose of selecting combat effective fighter pilots (see Section 5).

Equipment knowledge tests could be developed from tests of pilot skills, knowledges, and tasks which have been investigated. In addition to the aviation information components of the USAFOQT (AF PT 974, 1 Sep 73) in booklet 5, the special vocabulary tests which were used by the World War II

[2]For a tabular summary of paper-and-pencil personality tests, see Appendix E of Anastasi (1976).

researchers (Lepley, 1947) and by Korean War researchers (e.g., Torrance, Rush, Kohn, and Doughty, 1957) would be useful sources for the development of adequate tests of equipment knowledge.

7.2.2 Factors to be Tested by Small Apparatus and Job Sample Tests - Small apparatus tests are suggested for assessing factors within the domains of medical variables (ability to withstand physiological stress), decision making/information processing (selective attention, decision time, alertness), and sensory-motor abilities (visual perception, motor coordination, spatial orientation, spatial-perceptual ability, perceptual speed) (see Figure 7.2-1).

Physiological stress tests using small apparatus can be used for assessing the ability to withstand various physiological stresses involving vestibular, ergonomic, cardiovascular, and thermal stressors. Tests of these types have been used for selecting pilots for very special roles such as astronaut training. Significantly, some types of physiological stress tests appear to have an important psychological component. Anxiety responses to altitude chamber (a large apparatus test) experiences are common and a potential way of selecting out poor risk pilot candidates. Surprisingly, very simple (although painful) thermal stress experiences appear effective in discriminating between pilot candidates. For example, a substantial percentage of the more than thirty candidates bidding for the initial seven astronaut slots refused or would not endure a modest test (keeping their feet in icewater for approximately 20 minutes) of cold exposure.

Some information processing tests use small apparatus. Several of these tests are available for use in selecting pilots. Recently, Pew and Adams (1975) have identified six candidate information processing tasks which show promise for predicting success in flying training. Among those tasks are "manageability of attention" and "multiple-task management and workload capacity."

Manageability of attention includes two areas we have identified for testing fighter pilots, selective attention and alertness. Developments in the study of attention indicate that several reasonable measures are available for assessing this domain (Broadbent, 1971; Kahneman, 1973). These range from measures of pupil dilation and direction of gaze to target detection in a vigilance task. Moderately simple apparatus tests exist for obtaining these measures.

Tests of decision time and perceptual speed were investigated as tests for selecting combat effective pilots and found to be reasonable for that purpose (Lepley, 1947; Torrance, et al, 1957). A reaction to signals test was used for distinguishing fighters from non-fighters (Egbert, et al, 1957). Since equipment for this type of testing has become inexpensive and highly reliable, development of this class of test should be straightforward and relatively simple when compared with some other tests.

Visual perception is a very broad domain, but certain types of tests from this domain such as hidden figure tests (Jenkins, Ewart, and Carroll, 1950) and rod and frame tests (Pew and Adams, 1975) seem to hold promise for use in fighter pilot selection. These tests will provide a starting point for small apparatus perceptual test development in our proposed program.

Small apparatus tests of the sensory-motor variety are also available for use in pilot selection. This type of small apparatus test is recommended for assessing motor coordination, spatial orientation, and spatial-perceptual ability. During World War II, apparatus test measures were relatively efficient predictors of aviation combat performance. Tests producing the highest validity coefficients were the Complex Coordination, Finger Dexterity, and Rotary Pursuit tests, and the Army Spatial Orientation Test (Lepley, 1947; Torrance, et al, 1957). Although apparatus tests were discontinued

shortly after World War II due to technical and administrative problems, renewed interest in their development is presently being expressed (McGrevy and Valentine, 1974; Passey and McLaurin, 1966; Sanders, Valentine, and McGrevy, 1971). For example, a Complex Coordination test modeled after the one used during World War II has been developed (McGrevy and Valentine, 1974; Sanders, et al, 1971). Therefore, our present level of technology permits the use of apparatus tests for assessing these sensory-motor factors.

The job sample approach attempts to reproduce a segment of the actual job and to predict future performance on the basis of performance on that job segment. Job sample tests have many similarities to small apparatus tests although they tend to be more complex and expensive. Whereas the small apparatus test attempts to measure the capabilities underlying effective job performance, the job sample takes a more straightforward approach and yields direct measures of job performance. Six of the selection factors were recommended for testing by job sample techniques. Two of these were considered inappropriate for testing at the candidate entry level (see Figure 7.1-1). These factors, flight skills and quality of combat decisions, would require an extensive job sample on the level of an interactive air combat simulation. Flight aptitude and integration decisions could be tested using a job sample in a ground trainer (Air Force System Command, 1971). Long and Varney (1975) had significant success in predicting completion of UPT using a General Aviation Trainer and a five hour learning sample of flight tasks.

Instrument reading can be tested through the use of relatively low fidelity job sample simulators. Evidence from transfer of training studies (Prophet and Boyd, 1970) indicated equivalent training using complex high fidelity simulators and low-fidelity mockups.

Job sample devices for aerial gunnery have been analyzed to define the minimum requirements of an effective simulator for training (Ross and Whalen, 1976). This study indicated that perceptual factors as well as hand/eye coordination were important for successful aerial gunnery. The integration of both of these factors would require a fairly extensive simulation facility rather than a simple hand/eye coordination track and shoot system which could be handled by a small apparatus test.

7.2.3 Factors to be Tested by Situational Tests and Ratings - Situational tests are structured environments which simulate those which are expected to occur in real life (Anastasi, 1976; Fiske, 1954; OSS Assessment Staff, 1948; Weislogel, 1954). These types of tests differ from work samples in that the behaviors assessed are more global and complex, e.g., motivation, leadership. Although situational tests are among the more expensive testing devices, they provide an avenue for assessing factors which, to date, have presented challenging measurement problems.

Typically, behaviors in situational tests are assessed through objective measures of performance or through ratings by trained observers (Anastasi, 1976). We suggest that peer ratings be added as an additional assessment technique. Several studies report relatively high correlations between peer ratings and nonaviation combat performance (Katter and Holmon, 1954; Katz, Burke, and King, 1955; King, Campbell, Johnson, Klieger, and Yaukey, 1952; Pulliam and Mathers, 1976). However, these peer ratings are obtained after a lengthy period of interaction between military candidates. Situational tests provide a means of obtaining peer ratings within a shorter period of time to allow for the early selection of fighter pilots.

We recommend situational tests for assessing the factors listed in the last column of Figure 7.2-1. These factors fall within the domains of personality-leadership (responsibility for men in combat, physical and combat leadership), social variables (teamwork, sociability), reaction to stress (performance under stress, emotional control, ability to withstand psychological stress, anxiety tolerance), risk-taking (willingness to take a

calculated risk), motivation (determination/desire, self-discipline), and personality (aggressiveness, self-confidence, courage).[3]

One of the most impressive applications of situational tests is the Leaderless Group Discussion (Anastasi, 1976). In this technique, a group is given a topic to discuss within a predetermined period of time and the behavior of each individual is rated by an observer. This, and other types of leaderless group situations have been used to assess factors such as cooperation, teamwork, and leadership. The reliability of the Leaderless Group Discussion is reported to be relatively high and strong relationships have been found between ratings derived from this situation and ratings in military settings (Anastasi, 1976). Therefore, this type of situational test is recommended for testing personality-leadership (responsibility for men in combat physical and combat leadership) and social (teamwork, sociability) factors.

A second category of situational test which has been devised is the situational stress test. Validity data are scarce, and, when reported, poor correlations have been found (Anastasi, 1976). One possible explanation for these discouraging findings is that these tests are not sufficiently stressful. For example, one stress test used by the Office of Strategic Services (OSS Assessment Staff, 1948) was to frustrate military candidates by interfering with their performance during a cube assembly task. Examples of more stressful situational tests which may be employed are described by Berkun, Bialek, Kern, and Yagi (1962). Behavioral and physiological responses were monitored during five stressful situations. Four of these were life threatening. These consisted of a simulated radioactive fallout, a simulated forest fire, a simulated disruption of a military exercise by misdirected artillery shells, and a simulated aircraft emergency. The latter two situations produced the most severe stress reactions. Although the validity of these tests was not addressed, these data suggest that these types of situations may prove to be highly sensitive to differences in a number of factors. Included in this category are factors related to reaction to stress (performance under stress, emotional control, ability to withstand psychological stress, anxiety tolerance), risk taking (willingness to take a calculated risk), motivation (determination/desire, self-discipline), and personality (aggressiveness, self-confidence, courage).

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[3] In accordance with the code of ethics of the American Psychological Association and because of our concern for the well-being of candidates participating in such a testing program, extreme care will be exercised to ensure that the participants' dignity and welfare are respected. Deception of any candidate would only be used if necessary and then only after proper steps have been taken to ensure that the procedures would not be likely to cause serious and lasting harm to the candidate.

7.3 ACES AIR COMBAT MANEUVERING RANGE PERFORMANCE ASSESSMENT PROGRAM

The next step in the ACES program is to develop a combat effective pilot selection test battery from the profile of the ace fighter pilot described in Section 4. This test battery should be integrated into an overall selection data acquisition plan which keeps records of a pilot's progress and performance capabilities throughout his training career. While prediction to success in training is important as an interim step on the way to developing selection procedures for the combat effective pilot, it should not be used as the primary criterion for placement in fighter cockpits. Assignment to fighter aircraft should be based on combat-related criteria. The development of appropriate selection procedures, therefore, requires a major validation program based on these types of criteria. This validation program would identify which of the many factors included in the pilot selection test battery actually predicted performance in air-to-air combat. Plans for combat validation are given in Section 7.4 and must wait until an aerial conflict of major proportion occurs. As an intermediate validation step, we propose that an air combat surrogate, specifically the ACMR/I, be used to validate the pilot selection test battery. The ACMR/I has generally received very strong pilot endorsements (see Section 2 and Section 6.2). Validation on the ACMR/I would enhance our selection capability by allowing us to select applicants who not only have the necessary skills for success in training but also possess the skills and perceptual capabilities required for effective air-to-air combat. In addition to improving current selection procedures, data from the validated test battery will serve as a data base for the final validation against actual combat criteria.

7.3.1 Implementation of the ACES Selection Test Battery - Once the selection test battery discussed in Section 7.2 is developed, a testing program should be defined which would allow for the assessment of pilot candidates in a cost effective manner. The exact nature of this program will be a function of several factors. Among these are the number of candidates to be screened, funding levels available, the amount of change which will be permitted, and the feasibility of establishing a separate testing facility. Our analysis in Sections 7.1 and 7.2 indicated that, at the very least, a testing facility for the housing of small apparatus tests and a testing session for the administration of situational tests would be required. The final structure of the program will depend upon the definition of the selection test battery and the degree of military support with respect to the implementation of this program.

7.3.2 Peacetime Validation of the Pilot Selection Test Battery on the ACMR/I - The next step in the ACES program, after the implementation of the combat effective pilot selection test battery, is the peacetime validation phase. The use of success in undergraduate pilot training as a criterion for pilot selection, has proven unsatisfactory as a means of identifying the combat effective pilot. While successfully completing UPT is a necessary condition for becoming a pilot, it is not a sufficient condition for becoming combat effective. A performance criterion having a stronger relationship to combat success is needed to properly validate the test battery. Fortunately, the recent construction of the ACMR/I facilities has provided such a tool. These facilities (see Section 6.2) provide a means for controlled and monitored air-to-air combat where real time performance measures can be accurately determined. The ideal validation program would consist of an independent program on the order of ACEVAL-AIMVAL which evaluated the air-to-air capability of the pilots once their level of competency was adequate to handle the intricacies of the range. Realizing the cost of such a program when applied to the large number of fighter pilots which are matriculated each year, some compromise must be made. The proliferation of instrumented ranges seems to indicate a greater and greater emphasis on the use of this type of facility in the normal course of a pilot's combat crew training. The data required to provide estimates of pilot performance in the air combat role can be obtained with a modest increase in these training sorties. It is also possible that some of

the more advanced air combat simulators could be used instead of the air combat maneuvering ranges. The use of simulators would add a certain degree of control to the pilot evaluation program but at the cost of a loss in the degree of realism. Regardless of how good a simulator is, it is not the same thing as flying. The use of this option would require additional tests comparing performance on simulators with performance on the instrumented ranges. As indicated in Section 6.1, a program of simulation paralleling the ACEVAL-AIMVAL air combat maneuvering instrumentation program would provide such data. The simulation option is not recommended for use in the validation program, even if a high degree of relationship is found between performance on the simulator and performance on the ACMR/I. It must be remembered that we are selecting for combat effectiveness. The ACMR/I is, at a minimum, one step removed from combat flying. Simulation is still another order of abstraction of the tasks which must be performed in combat, and may not present a true picture of the characteristics required for effective combat flying.

The execution of an adequate validation effort requires a highly detailed performance assessment plan which considers the number of missions to be flown by each pilot, the opponent against which the mission will be flown, the mission scenarios, and what performance criterion measures must be obtained for the evaluation of performance. Detailed protocols for flight evaluation tests have been routinely generated by the Air Force. An excellent example of such a flight program plan can be found in the ACEVAL-AIMVAL planning documents (ACEVAL-AIMVAL, 1976) which are briefly reviewed in Section 6.2. While the final definition of the specifics of such a plan must wait until the scope of the entire program is determined, certain problems, particularly with the criteria for mission success, should be noted. One of the most important factors in evaluating a pilot's proficiency is the specification of exactly what you are evaluating his proficiency against. In an interactive air-to-air combat engagement, the capability of the aggressor pilot becomes a critical factor in this evaluation. Even in a group of highly selected pilots, such as the aggressor team currently serving the training function at Nellis Air Force Base, significant individual differences exist with respect to capability. Indeed, on any given day an individual aggressor pilot's capability can be up or down depending upon a number of undefined variables. To overcome this potential for variability in aggressor pilots, a rigid course of training must be instituted to make their performance as consistent as possible from encounter to encounter. Thus, if six engagements per candidate pilot are planned, each of the pilots should get, as closely as possible, the same set of engagements so that consistent test and evaluation experiences are encountered across all candidate pilots.

Another problem in evaluating air-to-air combat performance is the definition of what measure must be used to determine success. In our discussion of simulation reliability in Section 6.1.5, we indicated that a large number of measures are taken in an attempt to evaluate performance and that many of these did not yield reliable estimates of the performance they were supposed to measure. Of the measures reviewed, a composite advantage score (AMLS) derived by NASA, Langley, and kills were the most reliable measures. A measure similar to AMLS has been developed by the Navy for use in the ACMR. While this measure has not been validated as yet, it is, in principle, an excellent way of obtaining reliable air-to-air combat performance scores. Our discussions with instructor pilots indicate that, as a group, they do not believe any single criterion measure, or group of criterion measures, now identified, adequately evaluate air-to-air performance. They believe that each encounter, while often similar to a previous one, is a unique event and must be evaluated on that basis. While this may be true for training missions where specific mistakes can be pinpointed and evaluated as illustrative material, an evaluation program cannot, in principle, be made up of a large series of unique and nonrepeatable events. We believe that instructor pilots should have a role in evaluating the pilot performance in this program. However, procedures must be defined

to the extent that a group of instructor pilots rating the performance of a given encounter produce a consistent evaluation.

The use of novel scoring criteria should also be considered. One suggestion was to set up a series of scenarios where the pilot to be evaluated was required to fly against both average and excellent aggressor opponents. Success criteria, in this case, would be the capability to beat the poor or average opponent routinely and the ability to survive against the highly trained superior opponent.

The final peacetime evaluation program must, obviously, wait for a definition of the scope of the effort which could be funded. Regardless of the size of the effort, however, the above problems will have to be dealt with on some level. Many of these answers already exist, at least in preliminary form, and the major effort should be not to discover new answers but to implement, in a practical fashion, the state-of-the-art techniques.

7.4 ACES COMBAT CONTINGENCY VALIDATION PROGRAM

Researchers armed with accurate air combat effective selection test scores and other related predictor variables (such as the pilot's previous combat experience) will be in a position to validate these predictor scores in future air war confrontations.

However, great care must be taken to properly conduct the combat kills data acquisition segment of this program. Two global problems confront the researcher which materially influence how he should conduct the research and what data he must collect.

How the research must be conducted is influenced by the very nature of combat and the combat command. The researchers first predilection, of course, is to exercise some control over the situation to be investigated. The naive researcher might well think that it was appropriate for him to select particular pilots for particular combat missions. In a combat environment, this interference with a commander's prerogative would never be allowed. The combat commander must be free to accomplish his operational assignment in the manner in which he deems appropriate. Consequently, the researcher is forced into dealing with kill records as they have eventuated within the combat arena.[4]

This does not place the researcher in an untenable position in the case of air-to-air combat kills analysis. It does mean, however, that he must gather enough reliable data to allow the assessment of the relative effectiveness of pilots in a situation that is contaminated by a number of artifacts. Weiss (1966) quoting from Tolstoy's War and Peace rather nicely draws the picture.

> ". . . What science can there be in a matter in which, as in all practical matters, nothing can be defined and everything depends on innumerable conditions, the significance of which is determined at a particular moment which arrives no one knows when?"

It is not our intent to overemphasize the problems associated with this kind of research endeavor but rather to understand and underscore them from the outset so that we can develop a workable research approach. We can clearly see that the research team must work on a noninterference basis with any fighter command engaged in combat. However, we can identify, at the outset, the central data requirements which are necessary to specify adequate test samples. For example, we have discussed the issue of opportunity in considerable detail in this report and, certainly, any researcher preparing a combat data acquisition plan must specify a pilot's opportunity for kill as one of the principal data requirements.

It is our strong feeling that any research team, even when armed with a carefully contrived set of data requirements, must be made up of at least four different kinds of specialists: first, qualified research psychologists who can establish additional data requirements which may be necessitated by a particular set of operational circumstances within any given area of air combat operations; second, combat experienced pilots who, from experience with air warfare operations, can identify still other data requirements that are peculiar to the individual area of air combat operations; third, sufficiently senior military officers armed with the appropriate authority to collect these data to serve as team leaders; and fourth, qualified individuals, specifically charged with the responsibility for complete, thorough documentation.

Since there is a strong precedent in air warfare for the acquisition and authentication of data concerning air kills, we see no reason why combat validation kills data cannot be effectively gathered. It may be that the debriefing and kill authenticating team could be integrated with the statistical

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[4] It may eventuate that the combat commander will, in making pilot assignments to different types of missions (some richer in kill opportunities), "artifactually" make the sample of air-to-air combat pilots more homogeneous with respect to their selection test scores. If this occurs, it will make the researchers' job more difficult, but one they will have to live with.

data acquisition team we have already identified. The cooperation of the combat commander should not be too difficult to obtain since, after all, he will be the first beneficiary of these data. He will be able to know which of his pilots are doing the job for him, and under what circumstances.

Before outlining the essential data requirements in the projected theater of combat operations, it should be noted that a complete flight history of all pilots in any combat sample should be developed. Data from both Korea and Southeast Asia indicate that a pilot's flight history in terms of number of flight hours, previous combat, etc., has been related to combat effectiveness.

We have drawn upon the Strawbridge and Kahn (1955) study of combat effectiveness in the air war in Korea as a model for developing the data requirements inherent in the scientific and rigorous combat data collection program. Valuable guidelines can be drawn from their work with respect to the acquisition of appropriate data, and alternative approaches to the analysis of factors which have influenced the reliability of these kinds of data. We will use approaches developed in their article in defining the combat data requirements. These, as well as some data requirements needed to insure the reliability of the data, are summarized here in the text and in Figure 7.4-1.

Strawbridge and Kahn (1955) begin their approach by identifying the type of mission as an influence on kill opportunities. In Korea they reported that:

> ". . . Most MIGs were encountered on counter-air missions to MIG Alley, such missions afforded greatest opportunity for the individual to perform. A pilot who flew a disproportionately large number of reconnaissance. . . or rescue missions had much less opportunity to contact the enemy. Further, although a pilot may have flown a large number of counterair missions to MIG Alley, if he was assigned the flight position of wingman, his role was largely defensive and he had little opportunity to initiate fire on the enemy. It is clear that those pilots who flew counterair missions to MIG Alley as flight or element leaders had greatest opportunity.
>
> ". . .The tactical situation affected a pilot's opportunities. The presence of an enemy in MIG Alley, the ratio of friendly to enemy planes, the distance of the enemy at time of sighting, the disposition of the enemy for combat, all of these affected a pilot's opportunities. A pilot may have been leader of a counter-air mission to MIG Alley, but if an enemy were grounded or if they were disposed to seek sanctuary behind the Yalu River, no contact could be made." (p. 15)
>
> "[However,]. . . a successful patrol can be thought of as a linear sequence of events: sighting the enemy, encountering the enemy, firing on the enemy, and destroying the enemy." (p. 14)

From these observations, Strawbridge and Kahn (1955) identified total missions (M), sightings as leader (S), encounters as leader (E), firings (F), and weighted kills (K) as critical combat data requirements. A more detailed description of these data requirements may be found in Section 3.2.2.2. To these requirements we would add the corollary wingman data. Figure 7.4-1 shows a preliminary or provisional identification of the data requirements that are keyed to a quantitative thoroughgoing analysis of combat effectiveness. Many of the data requirements are the obvious ones, e.g., number of missions, number of kills. Other data requirements are directed at issues affecting opportunity for kills while still others affect the overall reliability of the kills data. The "Comments" column in Figure 7.4-1 provides thumbnail descriptions of why the particular data item is important, particularly, whether it relates to the key data analysis of kills, or it is collected as a data requirement to sort out confounding issues such as opportunity, or flight position.

The ACES Combat Contingency Validation Program which we have sketched out here is clearly provisional. However, it does supply a usable departure point for a more carefully contrived plan. Air Force efforts, both in World War II and, particularly, Korea, were "reflex actions." In spite of this, the products coming from both World War II and particularly the Korean conflict, were excellently conceived and executed. Indeed, they form a large

	COMMENT
1. PILOTS FULL NAME _____ RANK _____ SERIAL NUMBER _____	• RECORDS KEEPING CONFUSION, MISAWARDS TO SIMILARLY NAMED PILOTS HAVE BEEN FOUND TO OCCUR IN EARLIER STUDIES OF THIS TYPE.
2. DATE OF MISSION TIME MISSION INITIATED (TAKE-OFF TIME FIRST AIRCRAFT) _____ TIME MISSION ENDED (LANDING TIME LAST AIRCRAFT) _____	• NEEDED FOR AUTHENTICATION. • EXACT TIMES FOR AUTHENTICATION, DAY/NIGHT DETERMINATION AND MULTI-MISSION DAYS.
3. TYPE OF MISSION AIR TO AIR _____ AIR TO GROUND _____ RECONNAISSANCE _____ OTHER _____	• PRINCIPAL INTEREST AIR TO AIR. LOWER OPPORTUNITY FOR AIR KILLS ON OTHER MISSIONS; WHEN KILLS HOWEVER DATA ARE DESIRED.
4. MAKE UP OF MISSION TOTAL NUMBER OF AIRCRAFT _____ CONFIGURATION (e.g. 8 AIRCRAFT IN 2 FLIGHTS OF 4) _____ SPECIFICATION OF INTEGRAL FLIGHT MAKEUP OF SUBJECT PILOT AIRCRAFT NAME (FULL) RANK SERIAL NUMBER 1 LEADER _____ _____ _____ 2 WINGMAN _____ _____ _____ 3 ELEMENT LEADER _____ _____ _____ 4 ELEMENT WINGMAN _____ _____ _____	• KOREAN WAR ANALYSIS SHOWS RATIO OF FRIENDLY TO ENEMY AIRCRAFT INFLUENCES KILLS. • MISIDENTIFICATION OTHER FLIGHT MEMBERS FOUND RELATIVELY COMMON. • POSITION IN FLIGHT A MAJOR FACTOR RELATED TO KILLS.
5. TYPE OF AIRCRAFT FLOWN ABORT WHEN 1 _____ _____ _____ 2 _____ _____ _____ 3 _____ _____ _____ 4 _____ _____ _____	• OVERALL EFFECTIVENESS OF VARIOUS AIRCRAFT TYPES OF INTEREST. • ABORT DATA CHANGE CONFIGURATION OF THE FLIGHT. • ABORT DATA COULD BE COMPARED WITH INITIAL SELECTION TEST SCORES DIRECTLY.
6. ARMAMENT OF EACH AIRCRAFT TYPE NUMBER EXPENDED BOMBS _____ _____ _____ MISSILES _____ _____ _____ AMMUNITION _____ _____ _____	• ARMAMENT DATA CONCERNING MISSILES AND GUNS OF DIRECT INTEREST (IN THEIR EFFECTIVENESS). • MISSILES AND GUNS DATA REQUIRED FOR KILLS ANALYSIS.
7. UNIT DESIGNATION _____ CALL SIGN _____	• CHECK ON AUTHENTICITY OF DATA; CONFUSION OFTEN FOUND IN CORRECTLY IDENTIFYING OTHER FRIENDLY PARTICIPATING FLIGHTS.
8. WEATHER (HOW IT AFFECTED MISSION) _____ _____	• WAS THE WEATHER A FACTOR THAT INFLUENCED MISSION OUTCOME?
9. ENEMY GROUND FIRE (HOW IT AFFECTED MISSION) _____ _____	• WAS ENEMY GROUND FIRE A FACTOR THAT INFLUENCED AN AIR TO AIR MISSION?
10. CONTROLLER: NAME (FULL) _____ RANK _____ SERIAL NUMBER _____ EFFECTIVENESS IN DIRECTING ATTACK	• DID THE CONTROLLER INFLUENCE THE OUTCOME OF THE MISSION. • ARE THERE DIFFERENCES IN CONTROLLER "COMBAT EFFECTIVENESS."
11. OTHER FACTORS WHICH MAY HAVE INFLUENCED THE MISSION... COMMUNICATION: _____ _____ _____	• AS OTHER FACTORS WHICH MAY INFLUENCE MISSION OUTCOMES ARE IDENTIFIED, THEY SHOULD BE ENTERED IN THIS "STANDARD FORM."
12. AIR TO AIR MISSION REPORT • WERE ENEMY AIRCRAFT SIGHTED? YES____ NO____ • BY WHICH PILOT – GIVE FULL NAME AND SERIAL NO. _____ _____ • WHEN (EXACT TIME _____) • WHERE (MAP COORDINATES _____) • HOW MANY _____ • WHAT TYPES _____ ARMAMENTS _____ WING TANKS _____ • ENEMY HEADING _____ SPEED _____ ALTITUDE _____ • SUBJECT PILOT'S FLIGHT RIBS	• KEY COMBAT DATA REQUIREMENT.
	• KEY COMBAT DATA REQUIREMENT

- WERE ENEMY AIRCRAFT SIGHTED? YES____NO____
  - BY WHICH PILOT – GIVE FULL NAME AND SERIAL NO._____ _____
  - WHEN (EXACT TIME____ ____)
  - WHERE (MAP COORDINATES_____)
  - HOW MANY_____
  - WHAT TYPES_____ARMAMENTS_____WING TANKS_____
  - ENEMY HEADING_____SPEED_____ALTITUDE_____
- SUBJECT PILOTS FLIGHT WAS
  - WHERE (MAP COORDINATES____)
  - HIS HEADING_____SPEED_____ALTITUDE_____
- DISTANCE BETWEEN SUBJECT PILOTS FLIGHT AND ENEMY AT SIGHTING
- RELATIVE SUN POSITION AT SIGHTING_____
- WEATHER CONDITION AT SIGHTING_____
- TACTICS
  - WAS AN ENCOUNTER ATTEMPT MADE
    BY FRIENDLY____ BY ENEMY_____
  - WAS AN ENCOUNTER ATTEMPT MADE BY SUBJECT PILOT
    - AS LEADER_____
    - AS ELEMENT LEADER_____
    - AS WINGMAN 2____OR 4____

- KEY COMBAT DATA REQUIREMENT

13. RESULTS OF ENCOUNTER ATTEMPT

PILOT	ARMAMENT EXPENDED		RESULTS	
	MISSILES	GUNS	DESTROYED	DAMAGED
1				
2 (FULL NAME				
3 RANK &				
4 SERIAL NO.)				

- KEY DATA REQUIREMENT

- TIME (DATE____HOUR____MINUTE) AND LOCATION (MAP COORDINATES____) OF DESTROYED (____) OR DAMAGED (____) CLAIM.

- KEY AUTHENTICATING DATA

14. AUTHENTICATION SOURCE
  - PILOT OF OTHER AIRCRAFT ON MISSION
    NAME_____ RANK_____ SERIAL NO._____
  - OTHER
    - _____
    - _____
    - _____

- KEY TO OFFICIAL AWARD OF CREDIT

15. FRIENDLY LOSSES AND DAMAGES OF AIRCRAFT

AIRCRAFT	DESTROYED	DAMAGED	TIME	LOCATION
1				
2				
3				
4				

- FRIENDLY LOSSES OF PERSONNEL

PILOT	KIA	WOUNDED	SURVIVED BATTLE
1			
2			
3			
4			

- KEY DATA FOR DOING THE ANALYSIS FROM THE PERSPECTIVE OF IDENTIFYING PILOTS WHO ARE MOST LIKELY TO BE SHOT DOWN. THIS STUDY HAS THE ABILITY TO ASK WHO WILL BE COMBAT EFFECTIVE AND WHO WILL BE COMBAT INEFFECTIVE.

16. TACTICAL DESCRIPTION OF AIR TO AIR BATTLE IN WHICH ARMAMENTS WERE EXPENDED BY FRIENDLY AIRCRAFT
  - PILOT'S NARRATIVE DESCRIPTION_____
    _____
    _____

- PILOTS NARRATIVE DESCRIPTION, RECORDED (AND PROMPTED) BY A SPECIALLY TRAINED SPECIALIST PROVIDES INFORMATION THAT MAY "RULE OUT" "PARTICULAR MISSIONS" FROM THE "SCIENTIFIC" ANALYSIS OF THE KILLS DATA.

  - ANALYSIS OF QUANTITATIVE DATA WHEN AVAILABLE TO IDENTIFY GUNNERY AND SHORT AND LONG RANGE MISSILE CONDITIONS
    - DISTANCE FIRING INITIATED____AND TERMINATED FOR GUNS_____
    - WEAPONS SYSTEMS CONDITIONS (TO BE SPECIFIED)

- THESE DATA AFFORD AN ANALYSIS OF PILOT TECHNIQUE IN THE KILLS ANALYSIS, SUCH AS CLOSE IN VS LONG RANGE GUN ATTACKS AND MISSILE HITS/FIRINGS AS A FUNCTION OF VARIOUS WEAPONS SYSTEMS PARAMETERS.

17. DESCRIBE ANY OTHER FACTORS CONSIDERED RELEVANT. _____
    _____
    _____
    _____

- RECORD ANY OTHER DATA THAT MAY HAVE INHERENT USEFULNESS AND DATA THAT MAY "RULE OUT" PARTICULAR MISSIONS FROM THE "SCIENTIFIC" ANALYSIS.

FIGURE 7.4–1 ACES COMBAT VALIDATION DATA REQUIREMENTS FORM (PRELIMINARY)

basis of what we can say factually about the factors contributing to air combat effectiveness. However, the researchers, through no real fault of their own, had only very limited relevant information on the pilots prior to their entry into combat.

If the ACES program recommended in this report is implemented, researchers will be armed with selection test scores in virtually all of the domains or dimensions presumed to underlie combat effectiveness. Armed with these test scores and an effectively executed combat data acquisition validation program, researchers will, for the first time in history, be able to specify a definitive profile of the ace fighter pilot.

7.5 SUMMARY

In Section 4, 35 factors not adequately assessed within an existing pilot selection program were recommended for inclusion in the profile of the combat effective fighter pilot. Thirty-three of these factors could be evaluated upon entrance into pilot training. The remaining two factors (quality of combat decisions and flight skills) can best be tested at the end of pilot training or in advanced training.

A cost effectiveness analysis of selection tools for assessing these 33 factors was performed. This analysis was based upon four criteria:

a. Cost of application.
b. Ease of administration and impact on the present selection program.
c. Objectiveness of scores.
d. Historical validity of test instruments as means of measuring a particular selection factor.

Of seven test instruments which were evaluated, five were found to be cost effective (paper-and-pencil tests, peer and instructor ratings, situational tests, small apparatus tests, and job sample tests). Paper-and-pencil tests were recommended for evaluating five factors, small apparatus and job sample tests for evaluating 13 factors, and situational tests and ratings for evaluating 15 factors. A detailed list of the factors to be tested with these selection tools may be found in Figure 7.2-1.

An air combat effectiveness study (ACES) program is recommended which consists of two phases. One phase is the ACES Air Combat Maneuvering Range Assessment Program, a peacetime validation plan. In order to adequately validate the pilot selection test battery, criteria more closely related to combat performance than measures of success in training are required. Air combat maneuvering range/instrumentation facilities provide a means of developing such criteria. Using these facilities, air-to-air combat conditions can be controlled and objective performance measures obtained in real time can be monitored.

The second phase of the ACES program is the ACES Combat Contingency Validation Program, a combat validation plan. In developing the critical data requirements for this program, the Strawbridge and Kahn (1955) study of air combat effectiveness during the Korean conflict was used as a model. These include the number of total missions, sightings as leader, encounters as leader, firings, and weighted kills. A more detailed listing of these data requirements may be found in Figure 7.4-1.

The end result of the ACES program would be a definitive profile of the ace fighter pilot.

8.0 FINAL SUMMARY

This study has examined the issue of finding a more efficient method for selecting combat effective fighter pilots. Our research has identified a program which could be implemented for the selection of individuals at entry into the military who would prove to be effective air-to-air pilots.

Significant differences in individual capability have been found between pilots using equivalent equipment. During peacetime, the combat effective pilots would demonstrate their effectiveness in air combat maneuvering range engagements. We believe that these individuals will have the characteristics of those who will be successful in the combat arena.

Approximately five years of rigorous work, costing about as much as a single modern fighter aircraft, would be required to develop such a program. The development of a program of this nature would require the execution of several phases. These include a job analysis of the fighter pilot task, the generation of testable trait hypotheses, the development of predictors and peacetime and combat criteria, and validation and cross validation during peacetime and combat. The following phases were completed in this study:

a. An extensive and comprehensive job analysis of the fighter pilot using information obtained from validity studies, interviews, and questionnaires.

b. The development of testable trait hypotheses covering 12 content domains.

c. A cost effectiveness analysis of selection tools for testing these trait hypotheses.

d. An evaluation of the reliability of measures in simulators and in air combat maneuvering ranges/instrumentations for the development of peacetime criteria.

e. A review of aviation combat research for the development of combat criteria.

Additionally, programs were outlined for the execution of the peacetime and combat validation phases.

Five major sources of information were used to generate a comprehensive profile of the combat effective fighter pilot. A review of World War II, Korean, and Southeast Asian combat data was completed as was a review of U.S. military aviation selection research dating from World War II to the present time which focused upon the characteristics and critical skills predicting success in flight training. The latter literature was used as a source of hypothesis generation since, by implication, these factors might be related to combat effectiveness. We also reviewed the German and Japanese World War II aviation selection research programs as well as the current Israeli program. The final source of information was the set of questionnaire responses which were returned to us by 373 fighter pilots.

Using the data and inputs from these five sources, we created an integrated profile of the combat effective fighter pilot. In all, 45 factors distributed among 12 major domains (medical/physiological; aptitude; decision making; sensory-motor abilities; aviator skills, knowledges, and tasks; personality; personality-leadership; movitvation; reactions to stress; risk taking; social factors; and biographical data) can be hypothesized to be of predictive value in identifying the combat effective fighter pilot. Of these 45 factors, 35 are not adequately assessed in the entry selection program of the U.S. Air Force. Since the technological basis for testing the majority of these hypothesized predictor variables is at hand, we believe that a reasonable case has been made for the overall feasibility of such a program.

The most cost-effective selection test instrument for each particular hypothesized predictor variable was indicated. We found that an entry selection program could test for 33 of the 35

hypothesized predictor variables currently not sufficiently tested by the U.S. Air Force. This is a major finding of this study.

We have formulated an ACES Selection Test Program which would test for the 33 factors listed. We conceptualize such a selection test program as being similar to the current Israeli program, but more comprehensive. The ACES testing program could, after development, be conducted at a single site with candidates being tested during a seven to ten day period.

Once the selection test scores have been collected, candidate pilots would progress normally through conventional pilot training to a point where a substantial number of them could be placed in the ACES Pilot Air Combat Maneuvering Range Performance Assessment Program. Here the pilots would fly against specially trained instructor pilots in a series of carefully contrived air combat scenarios. Well-defined and accurately measured criterion scores would be generated as a measure of each pilot's combat effectiveness. After the peacetime data collection phase is completed, correlations between pilots' combat effectiveness scores and ACES Selection Test Program scores could be used to evaluate the predictive power of the ACES Selection Test Program. If, upon analysis, adequate correlations exist between pilot selection test scores and measures of performance during dissimilar air combat testing, then there will exist, during peacetime, a way of selecting pilots who will perform adequately in a necessary condition for combat success. Combined with appropriately small selection ratios, the probability of picking combat effective pilots can be greatly enhanced.

Finally, we have prepared a Combat Contingency Validation Plan. If a war should eventuate, we would relate the pilot's scores in both the ACES Selection Test Program and the ACES Pilot Air Combat Maneuvering Range Performance Assessment Program with performance in actual combat. The combat contingency validation plan includes a specification of the combat data requirements for adequate evaluation of the combat effectiveness of individual pilots, uncontaminated by such issues as opportunity.

The ACES Combat Contingency Validation Program which we have sketched here is provisional. We have, however, specified a reasonable departure point for a more carefully designed plan. No pre-war contingency research plans were available for World War II or for Korea. Despite this, the products coming from both air-to-air conflicts were quite useful. Without a good plan, however, only very limited relevant information on the pilots was available prior to their entry into combat.

If the ACES program is implemented, researchers will have selection devices assessing the dimensions presumed to underlie combat effectiveness. The military aviation research community would, for the first time in history, be in a position to specify an accurate profile of the combat effective fighter pilot.

9.0 GLOSSARY, REFERENCES, AND SUPPLEMENTAL BIBLIOGRAPHY

9.1 GLOSSARY

A-4 - Navy ground attack aircraft

A-6 - Navy ground attack aircraft

A-7 - Air Force ground attack aircraft

A-10 - Air Force ground attack aircraft

AAF - Army Air Force(s)

A/A - Air-to-Air

AAA - Anti-Aircraft Artillery

AAFQE - Army Air Force's Qualifying Examination

AB - Afterburner

AC - Aircraft or Aircraft Commander

ACB - Aircrew Classification Battery

ace - ordinarily, an American or Allied pilot with five or more aerial victories

ACES Program - Air Combat Effectiveness Study Program

ACEVAL - Air Combat Evaluation

ACEVAL-AIMVAL - Air Combat Evalaution - Air Intercept Missile Evaluation

ACF - Advanced Conventional Fighter

ACM - Air Combat Maneuver(ing)

ACMI - Air Combat Maneuvering Instrumentation

ACMR - Air Combat Maneuvering Range

ACMR/I - Air Combat Maneuvering Range/Instrumentation

ACMS - Air Combat Maneuvering Simulator

ADF - Advanced Day Fighter

ADI - Attitude Director Indicator

AFB - Air Force Base

AFHRL - Air Force Human Resources Laboratory

AFOQT - Air Force Officer Qualifying Test

AFTI - Advanced Fighter Technology Integration

AFWAB - Army Fixed Wing Aptitude Battery

AGL - above ground level

AIG - Aircraft Image Generation

AIM - Air Intercept Missile

AIMVAL - Air Intercept Missile Evaluation

AIP - Advanced Instructional Provisions

AIS - Aircraft Instrumentation Subsystem

AMAS - Alternate Manifest Anxiety Scale

AML - Adaptive Maneuvering Logic

AMLS - Adaptive Maneuvering Logic Score

AoA - Angle of Attack

AQT - Aviation Qualifying Test

ARMA - Adaptability Rating for Military Aeronautics

ARI - Army Research Institute

ARPA - Defense Advanced Research Projects Agency

ASDB - Army Self-Description Blank

ASUPT - Advanced Simulator for Undergraduate Pilot Training

ATC - Air Training Command

ATT - Advanced Technology Threat

AV-8A - designation code number of the Harrier aircraft

Axis Sally - turncoat propaganda broadcaster for Germans in World War II

B-17; B-29 - American bombers used in World War II and Korea

Bell 206-Jet Ranger - helicopter "trainer" used by the Israelis

BFM - Basic Flight Maneuvering

Betty - World War II - (designation) Japanese bombers

BI - Biographical Inventory

BPI - Bits per Inch

Britten-Norman Islander - aircraft used by Israelis for navigator training

CAA - Civil Aeronautics Administration

CAP - Combat Air Patrol

CCS - Control and Computation Subsystem

CCTS - Combat Crew Training School

CDC - Control Data Corporation

CEP - Circular Error, Probable

CG - Center of Gravity

Chofu unit - designation (location) of key Japanese aviation selection test unit in World War II

CO - Commanding Officer

Corsair - gull wing Navy and Marine fighter aircraft of World War II

CPI - California Personality Inventory

CPM - Cards per Minute

CRT - Cathode Ray Tube

Dassault Breguet Mirage - Advanced jet fighter aircraft used by Israelis

DC or dc - Direct Current

DCS - Deputy Chief of Staff

DDS - Display and Debriefing Subsystem

DF - direction finder/finding

DLC - Direct Lift Control

DM - Drag Modulation

DMS - Differential Maneuvering Simulator

DMT - Defense Mechanism Test

DOB - Differential Officer Battery

DOR - Drop on Request

Dornier Do27 - light twin engine plane used to train some Israeli pilots

Doves - ineffective combat pilots; those having a high probability of being shot down

Draw a Man Tests - standard psychological tests in which testee draws or completes a drawing of a person; a nonverbal test of intelligence

DSC - distinguished service cross

DSFC - Direct Side Force Control

EPI - Eysenck Personality Inventory

EPPS - Edwards Personal Preference Schedule

F-4 - American triservice fighter bomber

F-8 - Navy fighter

F-14 - modern Navy fighter aircraft

F-15 - modern Air Force fighter aircraft

F-86 - American jet fighter aircraft used extensively during the Korean War; the Sabre

F-100 - vintage Air Force jet fighter aircraft

F-105 - Air Force fighter

FAST - Flight Aptitude Selection Test

FAR - Flight Aptitude Rating (scale)

FAR - Fighter/Attack/Reconnaissance

FIP - Flight Indoctrination Program

F.I.W. - Fighter Interceptor Wing

Flak - antiaircraft fire; drawn from the German acronym

Fouga Magister - French designed, Israeli manufactured jet trainer

FW-190 - World War II German fighter aircraft

FWC - Fighter Weapons Center (Nellis AFB)

G-ratings - an overall assessment of pilot proficiency

GA - Gust Alleviation

GAT-1 - General Aviation Trainer, No. 1

GCA - Ground Control Approach

GCI - Ground Control Intercept

GIT - General Information Test

GPI - Gordon Personality Inventory

GZTS - Guilford-Zimmerman Temperament Survey

HAC - High Acceleration Cockpit

HAF - High Acceleration Fighter

Hamps - World War II Japanese Warplane (designation)

HAS - Heineman Anxiety Scale

Hawks - superior air-to-air fighter pilots (re Weiss, 1966)

HSI - Horizontal Situation Indicator

HUD - Head Up Display

HumRRO - Human Resources Research Organization

IAF - Israeli Air Force

ID - identification

IDIIOM - Information Displays Incorporated Input/Output Machine

I/O - Input/Output

IOQ - Interest-Opinion Questionnaire

IP - Instructor Pilot

IQ - Intelligence Quotient

IR - Infrared

JAAF - Japanese Army Air Force

JG - Jagdgeschwader (German Fighter Wing) 108 to 144 aircraft

JNAF - Japanese Navy Air Force

Kamakaze pilots - Japanese suicide pilots of World War II; the Devine Wind

KCAS - Knots Calibrated Air Speed

Kfir - Israeli front line air-to-air fighter aircraft

KIA - Killed in Action

Koku Tekisei Kensabu - World War II Japanese aviation test unit

KPR - Kuder Preference Record

LLLTV - Low Light Level Television

LQT - Large Quantity Threat

LTV - Ling Temco Vought, Inc.

Luftwaffe - the German Air Force

MACS - Manned Air Combat Simulator

MCAIR - McDonnell Aircraft Company

MCT - Mechanical Comprehension Test

MDC - McDonnell Douglas Corporation

ME-109 - World War II German fighter aircraft

ME-262 - German twin engine jet used as a fighter aircraft during the last period of World War II

MEC - Maneuver Enhancement Control

MIB - Military Interest Blank

MIG - designation of Russian fighter aircraft

MIG-17 - Russian fighter aircraft also designated as Fresco

MIG-21 - Russian fighter aircraft also designated as Fishbed

MIGCAP - MIG Combat Air Patrol

Mirage - French built front line Israeli fighter aircraft

MIT - Military Information Test

MMPI - Minnesota Multiphasic Personality Inventory

MSL - mean sea level

MSS - Missile Simulation Subsystem

NASA - National Aeronautics and Space Administration

Nates - World War II Japanese fighter aircraft (designation)

NATOPS - Navy Air Training and Operating Procedures Standardization

NAVAIR SYS COM - Naval Air Systems Command

NCO - Noncommissioned Officer

NMI - nautical miles

NVN - North Vietnam

NRC - National Research Council

OCS - Officer Candidate School

OER - Officer Efficiency Report

Ord. - ordnance

ORO - Operations Research Office

OSS - Office of Strategic Service

P - pilot

P-38, 39, 40, 47, 51 - American fighter aircraft of World War II

Pearsonian r - Pearson product moment correlation coefficient

Piper-PA-18-150 - light aircraft used by Israelis in early flight training

PK - Probability of kill

POW - Prisoner of War

PRB - Personnel Research Branch

Psychotechnics - Applied Psychology, e.g., in aviation selection

RAF - Royal Air Force (Britain)

R&R - rest and recuperation

RCAF - Royal Canadian Air Force

RDTMS - Rated Distribution Training Management System

Recce - reconnaissance

Red Baron Reports - see WSEG in Reference Section. SEA study program concerning air effectiveness

Red Flag Program - Triservice Combat Readiness Program being conducted at Nellis AFB

RIPS - Real Image Projection System

River Rat - member of the Red River Valley Fighter Pilots Association; must have flown missions over South Vietnam

ROTC - Reserve Officer Training Corps

RTU - Replacement Training Unit

SAC - Strategic Air Command

SAM - U.S. Air Force School of Aviation Medicine or surface-to-air missile

SAAC - Simulator for Air-to-Air Combat

SAS - Stability Augmentation System

SAT - Spatial Apperception Test

SCDC - Simulation Control and Data Center

SE - standard error of measurement

SEA - Southeast Asia

Sortie - one mission by a single plane

SOCON - Self-Other Concept Test

Split S - standard aerobatic combat maneuver

STG - Synthetic Terrain Generation

Stuka - German dive bomber used throughout World War II

TA-4 - trainer version of the A-4 aircraft

TAC - Tactical Air Command

TAC ACES II - Pilot training evaluation study using the simulator for air-to-air combat

TACAN - Tactical Air Navigation

TAT - Thematic Apperception Test

TIS - Tracking Instrumentation Subsystems

TMAS - Taylor Manifest Anxiety Scale

TO - Time-on-Offense

TOA - Time on Offense with Advantage

TOPLINE - Air Force Personnel Plan

Top Gun - Navy air combat training program

TTB - Transport/Tanker/Bomber

TV - Television

UHF - Ultra High Frequency

UPT - Undergraduate Pilot Training

USAF - United States Air Force

VACS - Vought Air Combat Simulator

VCS - Velocity Control System

VF - designation for Navy fighter squadron

VIPS - Virtual Image Projection System

VLF - Vectored Lift Fighter

VOR - Very High Frequency Omni-Directional Range

WSEG - Weapons System Evaluation Group

WSO - weapons systems operator

Zone of the Interior - the Continental United States

Zeke - (designation) World War II fighter aircraft

Zero - (designation) World War II Japanese fighter aircraft

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9.3.7.1 Proficiency Measurement

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APPENDIX 1.A

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New London, Connecticut 06340
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Wright-Patterson Air Force Base, Ohio 45433
(Joan C. Robinette)

Dr. E. Paul Torrance
Head, Department of Educational Technology
University of Georgia
Athens, Georgia 30602

USAF Academy, Colorado 80840
Department of Behavioral Sciences and Leadership
(Maj E. Galluscio)

USAF School of Aerospace Medicine
Brooks Air Force Base, Texas 78235
(Col Robert G. McIver)

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Arlington, Virginia 22209
(William B. Camm)

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Fort Rucker, Alabama 36362
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APPENDIX 3.A

STATISTICAL CALCULATIONS FOR THE ANALYSIS OF CHANCE ISSUES AS THEY RELATE TO AIR-TO-AIR KILLS SHOWN IN SECTION 3.0

3.A.1 NUMERICAL CALCULATIONS FOR KOREAN WAR DATA: PROBABILITY OF OBTAINING 792 ENEMY KILLS AND 78 USAF LOSSES IN 870 ENCOUNTERS

3.A.1.1 Using the General Formula for Chi Square:

$$\chi^2 = \Sigma\ (f-F)^2/F$$

where

f = Observed Frequency (kills or losses)

F = Expected Frequency (kills or losses based upon chance)

We calculate

$$\chi^2 = \frac{(792-435)^2}{435} + \frac{(78-435)^2}{435}$$

$$= \frac{(357)^2}{435} + \frac{(-357)^2}{435}$$

$$293 + 293$$

$$\boxed{\chi^2 = 586,\ df = 1,\ p < .001}$$

Rejection of the null hypothesis (i.e., observed frequencies lie within chance expectations) requires a Chi Square value of 10.83 at the .001 level of significance.

3.A.1.2 Using an Approximation to the Binomial Probability:

The exact probability of as extreme or more extreme a result may be computed using the binomial probability formula:

$$\sum_{i=r}^{n} \binom{n}{i} p^i q^{n-i}$$

where

n = the number of events (encounters)

r = the number of successes in n trials

p = the probability of a success (assumed to be .5)

q = the probability of a failure (assumed to be .5)

We could calculate

$$p = \frac{870!}{792!78!}\ .5^{870} \text{ plus 77 similar terms.}$$

Alternately we have chosen to compute a normal approximation to the binomial applying the Central Limit Theorem, thus:

$p(r \leq X \leq n) \doteq p(r - \frac{1}{2} \leq X \leq n + \frac{1}{2})$ which can be computed. . .

$$p(X \geq r) \doteq p\left(\frac{(r-\frac{1}{2})-\mu}{\sqrt{\sigma^2}} < Z < \frac{(n+\frac{1}{2})-\mu}{\sqrt{\sigma^2}}\right)$$

where

μ = the mean

σ^2 = the variance

Z = the standardized normal variate

We calculate

n = 870

p = .5

μ = 870 (.5) = 435

σ^2 = 870 (.5) (.5) = 217.5

$$p(X \geq 792) \doteq p\left(\frac{791.5-435}{\sqrt{217.5}} < Z < \frac{870.5-435}{\sqrt{217.5}}\right)$$

$$p\left(\frac{356.5}{14.75} < Z < \frac{435.5}{14.75}\right)$$

$$p(24.17 < Z < 29.53)$$

which is less than 0.0000001.

3.A.2 NUMERICAL CALCULATIONS FOR SOUTHEAST ASIA KILL DATA*: PROBABILITY OF OBTAINING 131 ENEMY KILLS AND AN ESTIMATED (FROM THE OPEN LITERATURE) 55 USAF AIR-TO-AIR LOSSES IN 186 ENCOUNTERS

3.A.2.1 Using the General Formula for Chi Square:

$$\chi^2 = \Sigma\ (f-F)^2/F$$

We calculate

$$\chi^2 = \frac{(131-93)^2}{93} + \frac{(55-93)^2}{93}$$

$$= \frac{(38)^2}{93} + \frac{(-38)^2}{93}$$

$$= 15.52 + 15.52$$

$$\boxed{\chi^2 = 31.04,\ df = 1,\ p < .001}$$

Rejection of the null hypothesis (i.e., observed frequencies lie within chance expectations) requires a Chi Square value of 10.83 at the .001 level of significance.

3.A.2.2 Using an Approximation to the Binomial:

$$p\ (X \geq r) \doteq p\left(\frac{r - \frac{1}{2} - \mu}{\sqrt{\sigma^2}} < Z < \frac{n + \frac{1}{2} - \mu}{\sqrt{\sigma^2}}\right)$$

where

$n = 186$

$p = .5$

$\mu = 186\ (.5) = 93$

$\sigma^2 = 186\ (.5)\ (.5) = 46.5$

We calculate

$$p(X \geq 131) \doteq p\left(\frac{130.5 - 93}{\sqrt{46.5}} < Z < \frac{186.5 - 93}{\sqrt{46.5}}\right)$$

$$p\left(\frac{37.5}{6.82} < Z < \frac{93.5}{6.82}\right)$$

$$p\ (5.49 < Z < 13.71)$$

which is less than 0.0000001.

*See Section 3.0, p.

APPENDIX 3.B
DESCRIPTION OF THE PERSONNEL RESEARCH BRANCH EXPERIMENTAL BATTERY*

3.B.1 PERSONALITY INSTRUMENTS

3.B.1.1 Army Self-Description Blank (ASDB) (Recruit) - A 279-item personality questionnaire consisting of items found valid on the basis of Arctic, Korean, and other item analysis data. The first 50 items are the most-least type of forced-choice based on 25 quintets of phrases. The next 183 items are of the Yes-No type, and the final 46 items consist of forced-choice pairs.

3.B.1.2 Army Self-Description Blank (ASDB) R-II - A suppressor instrument, consisting of 150 Yes-No personality items believed on the basis of previous item-analysis data to have possible suppressor characteristics (high correlation with the valid material, but low correlation with the criterion).

3.B.1.3 Interest-Opinion Questionnaire (IOQ) - HumRRO's personality instrument, derived from a multiplicity of source instruments, resulting from its Korean Fighter-Factor item analyses, consisting of 286 items in seven sections, each section using a different item type.

3.B.1.4 General Information Test (GIT) - A test developed under contract designed to measure interest in masculine-type outdoor activities (including military matters) by tapping knowledge that would presumably have been gained almost entirely by actual participation. There are 100 "positive" type items; and 20 "negative" or suppressor type items, tapping a "bookworm" or "dilettante" component.

3.B.2 REASONING TESTS

3.B.2.1 Practical Situations Test - A timed 25-item verbal reasoning test attempting to measure ability to solve practical problems, utilizing 4-choice questions.

3.B.2.2 Related Forms Test - An 84-item nonverabl reasoning test printed directly on the machine-scored answer sheet. In 28 groups of three items each, it requires the classification of each item (a geometrical pattern) into Type A or Type B according to a set of model patterns, with each of the 28 groups having its own set of Type A and Type B model patterns.

3.B.3 PERCEPTUAL SPEED TESTS

3.B.3.1 Reaction to Signals Test - A two-part, 210-item test of coding speed requiring the examinee to mark predesignated combinations of answers spaced for each item, according to a geometrical code signal (e.g., a triangle means to mark A, B, and C). Part I receives one minute of practice and four minutes of test time; Part II receives two minutes of practice and four minutes of test time.

3.B.3.2 Dials Test - A two-part, 60-item perceptual speed test in which each item requires the examinee to detect which one of four dial readings is in a danger zone as shown by shaded areas in four corresponding master dials.

3.B.3.3 Army Perceptual Speed Test, Form-2 - A 48-item test printed directly on the machine-scored answer sheet, in which each set of four items requires the examinee to match four groups of sketched objects with the proper four of five sketch groups from which they are taken.

3.B.3.4 Attention to Detail Test - A 60-item, hand-scored perceptual speed test of the "C-cancellation" type, scored rights only.

3.B.4 PERCEPTION IN DISTRACTION TESTS

3.B.4.1 Object Completion Test - A five-part, 75-item visual test requiring the examinee to recognize line drawings of military objects through checkered masks concealing 75%, 90%, 75%, 90%, and 75% of each picture in the respective parts.

*From Willemin, Birnbaum, and Rosenberg (1957)

3.B.4.2 Location Test - A 48-item visual test consisting of sets of four small photographs, each set being accompanied by a large photograph having five lettered locations marked. The examinee is required to identify the lettered location in the large photograph from which each of the four small photographs was taken. Six of the twelve sets of four small photographs are darkened to give a "night" effect.

3.B.4.3 Recognition Test - A combination visual and auditory test in three parts of 25 items each, requiring the examinee to recognize in each item which one of five drawings is being described on recorded tape, the recorded descriptions being accompanied by a variety of loud and annoying background sounds.

3.B.4.4 Weapons Idenfication Test - An auditory test recorded on tape, which teaches five weapons sounds to a point approaching saturation, and then tests the examinee's recognition of these weapons in ten parts of 15 items each. The parts are arranged in cyclical order, with Parts 1, 4, 7, and 10 being the easiest, Parts 2, 5, and 8 having the items in somewhat more rapid sequence, and Parts 3, 6, and 9 adding some artillery background.

3.B.5 TESTS INVOLVING PSYCHOMOTOR ABILITY

3.B.5.1 Patterns Test - A combined perceptual, spatial, and psychomotor measure requiring the examinee to reproduce, by freehand drawing in the lower portion of a machine-scored answer sheet, a series of line diagrams presented in the upper portion, making sure that the lines of the drawings go through answer spaces in the same way as do the master diagrams.

3.B.5.2 Two-Hand Coordination Test - An eye-hand coordination test requiring the examinee to place a stylus point in successive circles on the test sheet, moving left hand and right hand alternately, in three times parts of 25 seconds each.

APPENDIX 3.C

*p ≤ .05
**p ≤ .01

COMPARISONS OF FIGHTERS WITH NONFIGHTERS ON QUESTIONNAIRE - TYPE PERSONALITY TESTS‡

VARIABLE	GROUP WITH HIGHER SCORE: FIGHTERS	GROUP WITH HIGHER SCORE: NONFIGHTERS	P LEVEL ON t TESTS
CPI	(N = 162)	(N = 138)	
Academic Achievement	✓		
Delinquency		✓	*
Dissimulation		✓	**
Dominance	✓		
Femininity		✓	**
Flexibility	✓		
Good Impression	✓		
Graduate School Potential	✓		**
Honor Point Ratio	✓		*
Impulsivity		✓	**
Infrequency		✓	**
Intellectual Efficiency	✓		**
Neurodermititis		✓	*
Psychological Interest	✓		*
Responsibility	✓		**
Self Acceptance	✓		
Social Participation	✓		**
Social Presence - X_1	✓		**
Social Status	✓		*
Tolerance	✓		**
MMPI	(N = 161)	(N = 134)	
Academic Achievement	✓		
Caudality		✓	**
Delinquency		✓	**
Dependency		✓	**
Depression		✓	**
Dominance	✓		*
Dissimulation		✓	**
Ego Strength	✓		**
-F		✓	**
Feminity		✓	**
Honor Point Ratio	✓		*
Hypochondriasis		✓	**
Hypomania		✓	
Hysteria		✓	*
Intellectual Efficiency	✓		**
X_2 Impulsivity Self-Centeredness		✓	*
Graduate School Potential	✓		*
-K	✓		*
Leadership	✓		**
-L		✓	
Low Backache	✓		
Masculinity-Femininity		✓	**
Neurodermititis		✓	
Originality		✓	
Paranoia		✓	*
Parietal Lobe Damage		✓	**

‡This is based upon a table from Egbert, Meeland, Cline, Forgy, Spickler, & Brown (1957)

APPENDIX 3.C (CONTINUED)

VARIABLE	GROUP WITH HIGHER SCORE: FIGHTERS	GROUP WITH HIGHER SCORE: NONFIGHTERS	P LEVEL ON t TESTS
X_1 Poise, Spontaneity	✓		**
Psychasthenia		✓	**
Psychological Interest	✓		*
Psychopathic Deviate		✓	*
Responsibility	✓		
Role Playing	✓		**
Schizophrenia		✓	**
Schizophrenic Screening Scale		✓	*
Social Introversion		✓	**
Social Participation	✓		
Social Status	✓		**
Factor A		✓	**
Factor R		✓	
Tolerance		✓	**
HUMOR TEST	(N = 163)	(N = 138)	
Factor 1	✓		**
Factor 2		✓	**
Factor 3		✓	**
Factor 4		✓	*
Factor 5	✓		**
Factor 6	✓		
Factor 7		✓	*
Factor 8		✓	*
Factor 9		✓	*
Factor 10		✓	*
16 PERSONALITY FACTOR TEST	(N = 163)	(N = 137)	
Factor A		✓	
Factor B	✓		**
Factor C	✓		**
Factor E	✓		
Factor F	✓		
Factor G	✓		
Factor H	✓		
Factor I		✓	**
Factor L	✓		
Factor M		✓	*
Factor N	✓		**
Factor O		✓	**
Factor Q_1		✓	**
Factor Q_2	✓		
Factor Q_3	✓		
Factor Q_4		✓	

APPENDIX 3.C (CONTINUED)

VARIABLE	GROUP WITH HIGHER SCORE: FIGHTERS	GROUP WITH HIGHER SCORE: NONFIGHTERS	P LEVEL ON t TESTS
"MIB"			
INVENTORY P	(N = 160)	(N = 134)	
Mating		✓	
Escape-Fear	✓		**
Parental-Protective	✓		**
Appeal-Dependence		✓	
Curiosity		✓	*
Self-Assertion and Display		✓	
Gregariousness		✓	*
Self-Sentiment	✓		
Narcissistic Play		✓	
"MIT"	(N = 124)	(N = 91)	
	✓		**
INVENTORY OF PERSONAL PHILOSOPHY	(N = 163)	(N = 136)	
Fundamentalist Belief	✓		
Fundamentalist Disbelief		✓	
Enlightened Belief	✓		
Enlightened Disbelief		✓	
Complexity of Outlook		✓	
Extraception	✓		**
Artistic-Complex-Independence		✓	*
Chromatic		✓	
Simple-Obliging-Goodhearted	✓		
Liberalism		✓	
Romanticism		✓	
Intelligent Opinion	✓		
CALIF. PUBLIC OPINION SCALES	(N = 162)	(N = 135)	
Ethonce		✓	
Fascism		✓	*
Political-Economic Conservatism	✓		
SOCON	(N = 147)	(N = 124)	
"Self" Estimate	✓		*
Inferred "Others" Estimate	✓		
JUDGING PERSONALITY FILM	(N = 163)	(N = 135)	
Word List	✓		*
PERSONAL CHECK LIST	(N = 162)	(N = 136)	
		✓	
FIGURE PREFERENCE	(N = 165)	(N = 140)	
		✓	

APPENDIX 3.D

COMPARISONS OF FIGHTERS WITH NONFIGHTERS

IN A CLINICAL INTERVIEW *

ITEM AND RATING	PERCENT OF FIGHTERS	PERCENT OF NONFIGHTERS	P LEVEL ON t TESTS
BEHAVIOR DURING INTERVIEW			
IDENTIFICATION WITH COMBAT UNIT			
High	57	30	**
Above Average	26	27	
Below Average	11	22	*
Low	5	17	**
(Not Rated)	0	4	*
COGNITIVE ORGANIZATION			
High	40	23	**
Above Average	38	31	
Below Average	18	24	
Low	13	16	**
(Not Rated)	1	5	
BEHAVIOR IN INTERVIEW			
Indifferent	5	10	
Defensive	9	14	
Hostile	3	2	
Confused	5	11	
Cagey, Guarded	8	12	
Guilt - Ridden	4	7	
Cooperative	79	64	**
Sarcastic	4	2	
Smart-Alecky	5	4	
Uncooperative	8	5	
Dependent	21	33	*
Overly Cooperative	7	3	
Conscientious	47	33	*
Matter-Of-Fact	49	34	*
Tense and Nervous	10	16	
Self-Assured, Poised	40	16	**
Egotistical, Boastful	5	3	
Reserved, Dignified	16	12	
Infantile, Immature	13	12	
Conventional	21	21	
Interested	30	22	
Peculiar Mannerisms	7	14	
DRESS			
Neat	57	45	*
Casual	28	33	
Sloppy	5	9	
(Not Rated)	10	12	
POSTURE			
Relaxed	66	55	
Tense	16	26	
Other	7	6	
(Not Rated)	11	14	
Odd Features	8	5	

* This is based upon a table from Egbert, Meeland, Cline, Forgy, Spickler, & Brown (1957)

APPENDIX 3.D (CONTINUED)

ITEM AND RATING	PERCENT OF FIGHTERS	PERCENT OF NONFIGHTERS	P LEVEL ON t TESTS
USE OF WORDS			
Stumbling	1	10	**
Hesitant	19	32	**
Average	43	38	
Fluent	28	11	**
Verbose	2	1	
(Not Rated)	7	9	
RATE OF OUTPUT			
Slow	16	35	**
Medium	57	42	*
Fast	21	16	
Very Fast	1	0	
(Not Rated)	7	8	
SOCIAL-ECONOMIC LEVEL			
FAMILY BACKGROUND			
High Income Level	1	2	
Medium Income Level	52	36	**
Low Income Level	45	61	**
(Not Rated)	1	1	
Stable Income	32	19	*
Variable Income	47	52	
Erratic Income	18	28	*
(Not Rated)	3	2	
INCOME SOURCE			
Professional High	1	3	
Professional Low	3	2	
Business High	7	4	
Business Low	6	7	
Industrial High	21	9	**
Industrial Low	34	40	
Agriculture High	13	9	
Agriculture Low	14	22	
Other	1	0	
(Not Rated)	2	4	
BY FIELD COMBINING LEVELS			
Professional	4	5	
Business	13	11	
Industrial	55	49	
Agriculture	27	31	
BY LEVEL COMBINING FIELDS			
High	42	25	**
Low	54	71	**
QUALITY OF RESIDENCE			
High	1	2	
Middle Class	58	33	**
Low	40	59	**
(Not Rated)	2	5	

APPENDIX 3.D (CONTINUED)

ITEM AND RATING	PERCENT OF FIGHTERS	PERCENT OF NONFIGHTERS	P LEVEL ON t TESTS
PREVIOUS WORK BEFORE THE ARMY			
Farm Labor	10	11	
Menial Labor	1	8	**
Unskilled Labor	35	36	
Semiskilled Work	32	28	
Skilled Trade	5	2	
HOME ENVIRONMENT			
LOCATION OF RESIDENCE			
Large City	22	22	
City	24	21	
Town	22	26	
Rural	30	29	
(Not Rated)	1	2	
INTELLECTUAL CLIMATE			
High	1	0	
Medium	47	27	**
Low	49	69	**
(Not Rated)	3	4	
THE FAMILY			
A Complete Family Unit In A Fairly Normal Home	68	52	**
Not A Complete Family Unit In A Fairly Normal Home	31	47	**
(Not Rated)	1	1	
DISTANCE FAMILY HAS MOVED			
Little Or None	47	48	
Some Change	26	26	
Much Change	18	10	
Complete Break	8	15	
FREQUENCY OF FAMILY MOVES			
Often	13	12	
A Few Times	20	24	
Rarely Or Never	67	62	
(Not Rated)	1	0	
COMMUNITY ACTIVITIES			
Father's Participation			
Joiner	14	11	
Average	65	55	
Isolate	13	13	
(Not Rated)	9	21	**
Father's Position			
Leader	22	12	*
Follower	26	28	
(Not Rated)	52	61	
Mother's Participation			
Joiner	13	12	
Average	71	64	
Isolate	14	15	
(Not Rated)	4	9	

APPENDIX 3.D (CONTINUED)

ITEM AND RATING	PERCENT OF FIGHTERS	PERCENT OF NONFIGHTERS	P LEVEL ON t TESTS
Mother's Position			
Leader	22	14	
Follower	23	31	
(Not Rated)	55	54	
Subject's Participation			
Joiner	17	7	*
Average	65	68	
Isolate	16	17	
(Not Rated)	2	7	
Subject's Position			
Leader	24	17	
Follower	21	25	
(Not Rated)	55	58	
STRENGTH OF FAMILY KINSHIP TIES			
High	40	20	**
Medium	46	60	*
Low	14	16	
(Not Rated)	0	5	*
AMOUNT OF INTERACTION BETWEEN THE FAMILY AND OTHER RELATIVES			
High	41	28	*
Medium	41	47	
Low	18	21	
(Not Rated)	0	4	*
MARITAL STATUS OF PARENTS			
Together	71	64	
Separated	9	11	
Divorced	9	8	
Never Married	11	18	
DEATH OF PARENT WHILE SUBJECT GROWING UP			
Father Dead	15	28	**
Father Alive	85	72	**
Mother Dead	7	12	
Mother Alive	94	88	
FATHER-MOTHER RELATIONSHIP			
Excellent	22	18	
Average	49	43	
Hostile	7	13	
Ambivalent	8	9	
(Not Rated)	14	18	
EXPRESSION OF FATHER-MOTHER RELATIONSHIP			
Overt	55	58	
Covert	21	13	
(Not Rated)	24	29	

APPENDIX 3.D (CONTINUED)

ITEM AND TRAINING	PERCENT OF FIGHTERS	PERCENT OF NONFIGHTERS	P LEVEL ON t TESTS
HEALTH OF FATHER			
Chronic Physical Illness	38	35	
Chronic Mental Illness	1	1	
Alcoholism	8	9	
Short-Term Illness	15	12	
Other Conditions	3	1	
HEALTH OF MOTHER			
Chronic Physical Illness	35	38	
Chronic Mental Illness	1	2	
Alcoholism	2	2	
Short-Term Illness	11	13	
Other Conditions	2	2	
SUBJECT-FATHER AFFECT			
INTENSITY			
High	30	16	*
Medium	51	53	
Low	11	16	
(Not Rated)	9	16	
FATHER SEEN AS			
Easy Going	43	39	
Introverted	9	9	
Strict	19	22	
Nervous	9	3	*
Disinterested	7	10	
Strong	31	20	*
Demanding	8	9	
Short-Tempered	22	22	
Neurotic	7	5	
Vain	3	0	
MOTHER SEEN AS			
Warm	59	47	*
Domineering	2	7	*
Neurotic	11	9	
Overprotective	10	16	
Suspicious	1	4	
Confident	11	9	
Anxious	42	32	
Patient	34	27	
Understanding	41	36	
Cruel	0	2	
NUMBER OF OLDER MALE SIBLINGS			
None	26	23	
1	23	23	
2	18	15	
3	10	9	
4	4	5	
5-9	4	2	
(Not Rated)	15	22	

APPENDIX 3.D (CONTINUED)

ITEM AND RATING	PERCENT OF FIGHTERS	PERCENT OF NONFIGHTERS	P LEVEL ON t TESTS
NUMBER OF OLDER FEMALE SIBLINGS			
None	22	26	
1	26	20	
2	16	14	
3	9	9	
4	4	6	
5-9	5	6	
(Not Rated)	18	20	
NUMBER OF YOUNGER MALE SIBLINGS			
None	25	21	
1	29	30	
2	18	16	
3	4	5	
4	1	2	
5-9	2	3	
(Not Rated)	21	22	
NUMBER OF YOUNGER FEMALE SIBLINGS			
None	21	28	
1	39	25	*
2	13	16	
3	8	6	
4	3	3	
5-9	0	1	
(Not Rated)	18	21	
FATHER SEEN AS			
Successful Respected	55	47	
Essentially Mediocre	33	29	
Unsuccessful or Disgraced	5	5	
(Not Rated)	7	22	**
Forceful Personality	33	29	
Average Personality	48	43	
Ineffectual Personality	9	9	
(Not Rated)	10	17	
MOTHER SEEN AS			
Efficient Homemaker	69	47	**
Average Homemaker	25	43	**
Inefficient Homemaker	2	3	
(Not Rated)	4	6	
Forceful Personality	24	23	
Average Personality	63	60	
Ineffectual Personality	8	10	
(Not Rated)	5	7	
PUNISHMENT SUBJECT RECEIVED			
Amount			
High	9	22	**
Medium	66	56	
Low	22	19	
(Not Rated)	2	3	

APPENDIX 3.D (CONTINUED)

ITEM AND RATING	PERCENT OF FIGHTERS	PERCENT OF NONFIGHTERS	P LEVEL ON t TESTS
Consistency			
Consistent	59	48	
Average	32	36	
Erractic	7	11	
(Not Rated)	3	4	
Kind			
Physical	72	72	
Confinement	21	22	
Verbal	39	25	*
Deprivation	20	19	
Source			
Father	38	26	*
Mother	28	40	*
Both	27	26	
Other	5	5	
(Not Rated)	3	2	
Reasonableness			
Reasonable	51	46	
Average	45	44	
Irrational	3	5	
(Not Rated)	3	5	
THE SINGLE MOST IMPORTANT SOURCE OF SEX EDUCATION			
Father	7	2	*
Mother	3	2	
Teacher	1	1	
Peers	23	22	
Literature	2	3	
Personal Experience	19	23	
Other	2	2	
(Not Rated)	43	45	
SOURCE OF SEX EDUCATION			
Father	24	10	**
Mother	16	5	**
Teacher	9	4	
Peers	64	75	*
Literature	12	11	
Personal	36	39	
Other	6	4	

	FIGHTERS	NONFIGHTERS	P LEVEL ON t TESTS
Subject's age in years at time of separation or divorce of parents	N = 28 M = 10.0	26 7.7	
Age in years at time of father's death	N = 24 M = 11.8	40 10.3	
Age in years at time of mother's death	N = 11 M = 12.1	18 10.2	
Number of siblings subject has	N = 160 M = 4.6	138 4.7	

APPENDIX 3.D (CONTINUED)

ITEM AND RATINGS	PERCENT OF FIGHTERS	PERCENT OF NONFIGHTERS	P LEVEL ON t TESTS
RELIGION			
RELIGIOUS AFFILIATION			
Subject's			
Protestant-Established	47	57	
Protestant-Splinter	11	13	
Catholic	32	20	*
Jewish	0	2	
None	7	5	
Other	3	1	
(Not Rated)	1	2	
Father's			
Protestant-Established	44	53	
Protestant-Splinter	9	11	
Catholic	32	17	**
Jewish	0	2	
None	9	4	
Other	1	1	
(Not Rated)	5	12	*
Mother's			
Protestant-Established	51	58	
Protestant-Splinter	10	14	
Catholic	35	20	
Jewish	0	3	
None	4	1	
Other	0	1	
(Not rated)	5	4	
DOER SYNDROME			
PARTICIPATION IN SPORTS			
High	40	28	*
Medium	38	47	
Low	21	22	
(Not Rated)	1	3	
TYPE OF SPORTS MOST PREFERRED			
Body Contact	46	32	*
Other	36	45	
(Not Rated)	18	23	
PREVIOUS WORK BEFORE THE ARMY			
Clerical	4	11	*
Managerial	1	2	
Owned A Business	2	0	
Owned A Farm	1	2	
Student In College	2	0	
No Job Before Army	6	2	
(Not Rated)	1	0	

APPENDIX 3.D (CONTINUED)

ITEM AND RATING	PERCENT OF FIGHTERS	PERCENT OF NONFIGHTERS	P LEVEL ON t TESTS
FUTURE OCCUPATIONAL GOAL			
Farm Labor	0	1	
Menial Labor	1	1	
Unskilled Labor	7	5	
Semiskilled Work	16	20	
Skilled Trade	12	12	
Clerical Work	1	6	*
Managerial	1	0	
Owned A Business	13	10	
Owned A Farm	15	10	
"My Old Job"	8	9	
School, Then?	3	6	
Professional	7	4	
Stay In Military	9	5	
No Plans	7	12	
(Not Rated)	1	0	
HEALTH AND VITALITY			
PHYSICAL CONDITION			
Excellent	45	32	*
Medium	48	50	
Poor	8	16	*
(Not Rated)	1	0	
PARTICIPATION IN SPORTS			
High	40	28	*
Medium	38	47	
Low	21	22	
(Not rated)	1	3	
TYPE OF SPORTS MOST PREFERRED			
Body Contact	46	32	*
Other	36	45	
(Not Rated)	18	23	
HEALTH WHILE GROWING UP			
Excellent	63	53	
Medium	30	38	
Poor	3	5	
(Not Rated)	3	3	
Usual Childhood Illnesses	51	55	
A Single Serious Illness	22	20	
A Chronic Illness	7	6	
VITALITY			
High	41	21	**
Medium	53	69	**
Low	5	9	
(Not Rated)	1	2	

APPENDIX 3.D (CONTINUED)

ITEM AND RATING	PERCENT OF FIGHTERS	PERCENT OF NONFIGHTERS	P LEVEL ON t TESTS
SOCIAL AND EDUCATIONAL HISTORY			
SUBJECT'S BEHAVIOR IN SCHOOL			
High } Grade In School	16	10	
Average }	69	66	
Low }	15	22	
(Not Rated)	0	2	
INVOLVEMENT IN SCHOOL			
High	18	16	
Medium	46	47	
Low	36	36	
(Not Rated)	1	2	
SOCIAL TONE IN SCHOOL			
Positive	45	36	
Average	35	43	
Negative	20	19	
(Not Rated)	0	2	
SOCIAL PROFICIENCY IN SCHOOL			
High	25	10	**
Medium	45	70	**
Low	16	18	
(Not Rated)	0	2	
SOCIAL CONFORMITY IN SCHOOL			
High	19	17	
Medium	61	65	
Low	17	15	
(Not Rated)	3	2	
PARENTAL EXPECTATIONS AS TO GRADES IN SCHOOL			
Much	21	20	
Medium	72	66	
Little	7	11	
(Not Rated)	1	3	
PARENTAL EXPECTATIONS AS TO ULTIMATE LEVEL OF ACHIEVEMENT			
Much	37	31	
Medium	56	55	
Little	7	10	
(Not Rated)	0	3	
AGE OF CHILDHOOD ASSOCIATES			
Younger	9	6	
Contemporary	76	82	
Older	12	8	
Adult	0	1	
(Not Rated)	3	3	

APPENDIX 3.D (CONTINUED)

ITEM AND RATING	PERCENT OF FIGHTERS	PERCENT OF NONFIGHTERS	P LEVEL ON t TESTS
QUALITY OF CHILDHOOD ASSOCIATES			
High	5	2	
Average	73	80	
Delinquent	22	15	
(Not Rated)	1	3	
SIZE OF "GANG"			
Large Group	25	23	
Small Group	57	47	
Individual	16	22	
Isolate	2	5	
(Not Rated)	0	2	
POSITION OF SUBJECT IN HIS "GANG"			
Leader	19	14	
Variable	67	65	
Follower	9	15	
(Not Rated)	5	6	
MARITAL STATUS OF SUBJECT			
Married	25	26	
Single	71	71	
Separated	2	2	
Widower	0	0	
Divorced	1	2	
NUMBER OF CHILDREN SUBJECT HAS			
None	9	5	
1	11	9	
2	2	2	
3	1	2	
4	0	1	
Not Married	78	81	
WHEN AND HOW MARRIED			
Church	17	15	
Civil Ceremonies	11	10	
At Home	1	3	
Not Married	71	72	
ATTITUDE TOWARD PREGNANCY AND CHILDREN			
Positive	20	16	
?	4	5	
Negative	1	4	
-	75	74	
MARITAL ADJUSTMENT			
Very Good	17	13	
O.K.	6	7	
Not So Good	1	2	
Poor	5	2	
(Not Rated)	71	75	

APPENDIX 3.D (CONTINUED)

ITEM AND RATING	PERCENT OF FIGHTERS	PERCENT OF NONFIGHTERS	P LEVEL ON t TESTS
CROSS-CULTURAL MARRIAGES			
Yes	1	2	
No	28	26	
(Not Rated)	72	72	
CROSS-RELIGIOUS MARRIAGE			
Yes	5	5	
No	23	23	
(Not Rated)	72	72	
LIFE INFLUENCES			
Miscellaneous	6	7	
The Army, Positive or Neutral Mention	16	12	
The Army, Negative Mention	5	5	
Commitment to a Relationship with a Woman	6	5	
Termination of a Relationship with a Woman	5	3	
Unpleasant Experiences, General	7	5	
Parental Guidance	7	11	
The Combat Experience	3	2	
An Ego Ideal Other Than Parents	5	2	
Becoming Independent Before The Army	5	3	
Don't Know, Can't Say	3	5	
(Not Rated)	32	40	

	FIGHTERS	NONFIGHTERS	P LEVEL ON t TESTS
Age in years at time of first sex experience	N = 81 M = 15.8	59 14.3	**
Subject's age in years at time of marriage	N = 48 M = 19.7	40 20.6	*
Wife's age in years at time of marraige	N = 47 M = 18.3	40 18.7	
Time in months that wife was known before marriage	N = 47 M = 27.0	40 35.9	
Length of engagement in months	N = 46 M = 7.9	37 8.1	
Interval in months between marriage and wife's pregnancy	N = 23 M = 9.2	18 6.3	

APPENDIX 3.E
STATISTICAL RESULTS OF ROTARY WING PILOT SELECTION STUDIES FOR THE PREDICTION OF SUCCESS IN TRAINING

			CRITERION							
DOMAIN	REFERENCE AND STATISTIC	PREDICTOR	PASS-FAIL/ATTRITE	FLIGHT DEFICIENCY ELIMINATION	FLIGHT DEFICIENCY, ACADEMIC, AND MILITARY ELIMINATION	GRADES-FLIGHT	GRADES-OVERALL	LEADERSHIP/OFFICER RATING	TIME TO CHECKRIDE	TRAINING PHASE
APTITUDE	BOYLES AND WAHLBERG (1971) [r, N = 688–715]	FLIGHT APTITUDE SELECTION TEST: MECHANICAL INFORMATION MECHANICAL FUNCTIONS	 .09/.11 .14/.15							 FLIGHT
	KAPLAN (1965) [r]	FLIGHT APTITUDE SELECTION TEST-COMPOSITE	.42/.48							FLIGHT
REACTION TO STRESS	BOYLES (1968) [r, N = 299] [t, N = 408]	BACKGROUND ACTIVITIES INVENTORY		 2.33*				.22*		BASIC
	BOYLES (1969) [t, N = 311]	BACKGROUND ACTIVITIES INVENTORY: EXPOSURE SCORE RAW CONFIDENCE SCORE OVERALL CONFIDENCE SCORE		 2.16* 2.66* 2.18*						BASIC
	[r, N = 311]	EXPOSURE SCORE RAW CONFIDENCE SCORE		.09/.16 .10/.16						
	[t, N = 311]	SITUATIONAL CONFIDENCE: M-14 RIFLE AUTOROTATION		 2.01* 2.23*						
	[r, N = 311]	M-14 RIFLE AUTOROTATION		.08/.13 .12/.21						
	BOYLES AND WAHLBERG (1971) [r, N = 688–715]	BACKGROUND ACTIVITIES INVENTORY	.07/.08							FLIGHT
SOCIAL	WAHLBERG, BOYLES, AND BOYD (1971) [r, N = 108]	POTENTIAL AVIATOR RATING CONTEMPORARY EVALUATION FORM	.29/.44** .33/.41**		.38/.49** .35/.45**			.83/.91		PRIMARY
AVIATOR SKILLS, KNOWLEDGES, AND TASKS	BOYLES AND WAHLBERG (1971) [r, N = 688–715]	FLIGHT APTITUDE SELECTION TEST: INSTRUMENT COMPREHENSION VISUALIZATION OF MANEUVERS HELICOPTER KNOWLEDGE AVIATION INFORMATION	 .12/.14 .04/.06 .10/.14 .10/.13							FLIGHT
	[r, N = 688]	FLIGHT GRADES	.29/.45							
JOB SAMPLE	PROPHET (1969) [r]	HOVERING TRAINER						.52*/.62* .38*/.47* .44*/.48*	.60* .44* .44*	PRE-SOLO INTERMEDIATE ADVANCED
SENSORY-MOTOR	BOYLES AND WAHLBERG (1971) [r, N = 688–715]	FLIGHT APTITUDE SELECTION TEST: COMPLEX MOVEMENTS STICK AND RUDDER ORIENTATION	 .17/.20 .20/.22							FLIGHT
	ZEIDNER, MARTINEK, AND ANDERSON (1958) [r, N = 159]	ROTARY PURSUIT RUDDER CONTROL DIRECTION CONTROL COMPLEX COORDINATION	.30* .39* .15 NS .41*							FLIGHT
MULTIPLE PREDICTION	BOYLES (1969) [CUMULATIVE R, N = 945]	FLIGHT APTITUDE SELECTION TEST BACKGROUND ACTIVITIES INVENTORY:EXPOSURE SCORE SITUATIONAL CONFIDENCE: M–14 RIFLE AUTOROTATION		.27 .28 .29 .30						BASIC
	BOYLES AND WAHLBERG (1971) [CUMULATIVE R, N = 715]	FLIGHT APTITUDE SELECTION TEST: COMPLEX MOVEMENTS STICK AND RUDDER ORIENTATION MECHANICAL FUNCTIONS AVIATION INFORMATION BACKGROUND ACTIVITIES	 .20 .25 .27 .27							FLIGHT

SENSORY-MOTOR	BOYLES AND WAHLBERG (1971) [r, N = 688–715]	FLIGHT APTITUDE SELECTION TEST: COMPLEX MOVEMENTS STICK AND RUDDER ORIENTATION	 .17/.20 .20/.22							FLIGHT
	ZEIDNER, MARTINEK, AND ANDERSON (1958) [r, N = 159]	ROTARY PURSUIT RUDDER CONTROL DIRECTION CONTROL *COMPLEX COORDINATION*	.30* .39* .15 NS .41*							FLIGHT
MULTIPLE PREDICTION	BOYLES (1969) [CUMULATIVE R, N = 945]	FLIGHT APTITUDE SELECTION TEST BACKGROUND ACTIVITIES INVENTORY:EXPOSURE SCORE SITUATIONAL CONFIDENCE: M–14 RIFLE AUTOROTATION	 	.27 .28 .29 .30						BASIC
	BOYLES AND WAHLBERG (1971) [CUMULATIVE R, N = 715]	FLIGHT APTITUDE SELECTION TEST: COMPLEX MOVEMENTS STICK AND RUDDER ORIENTATION *MECHANICAL FUNCTIONS* AVIATION INFORMATION BACKGROUND ACTIVITIES INVENTORY	 .20 .25 .27 .27 .28							FLIGHT
	[CUMULATIVE R, N = 688]	FLIGHT GRADES FLIGHT APTITUDE SELECTION TEST: STICK AND RUDDER ORIENTATION MECHANICAL FUNCTIONS MECHANICAL INFORMATION HELICOPTER KNOWLEDGE	.45 .47 .48 .50 .51							
	DEES AND DUFILHO (1975) [R, N = 500-913]	RANK, AGE, MONTHS PRIOR SERVICE, EDUCATION (YEARS), PRIOR FLIGHT TRAINING, FLIGHT APTITUDE SELECTION TEST, *GENERAL TECHNICAL SCORE*, NUMBER OF DEPENDENTS, ARMED FORCES QUALIFICATION TEST, MARITAL STATUS, PROCUREMENT SOURCE, AIRMANSHIP EXAMS, WARRANT OFFICER DEVELOPMENT EXAMS, AND FLIGHT GRADES	.17/.48				.38/.80			PRE-FLIGHT TO PRIMARY
	[R, N = 603]	AGE, MONTHS PRIOR SERVICE, PRIOR FLIGHT TRAINING, EDUCATION, MARTIAL STATUS, AIRMANSHIP EXAMS, OFFICER DEVELOPMENT EXAMS, AND FLIGHT GRADES	.00/.35				.28/.86			PRE-FLIGHT TO PRIMARY

N = SAMPLE SIZE
r = THE DEGREE OF RELATIONSHIP BETWEEN A PREDICTOR AND A CRITERION (CORRELATION COEFFICIENT)
t = A TEST OF DIFFERENCES BETWEEN MEANS
R = THE DEGREE OF RELATIONSHIP BETWEEN TWO OR MORE PREDICTORS (COMBINED) AND A CRITERION (MULTIPLE CORRELATION)
NS = $p > .05$
* = $p \leqslant .05$
** = $p \leqslant .01$

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APPENDIX 5.A

PRELIMINARY STATISTICAL ANALYSIS FOR THE DEVELOPMENT OF THE PILOT LIFE INVENTORY QUESTIONNAIRE (SHORT FORM)

In a preliminary effort to refine the original 141 item Life Experience Inventory, this device was administered to a small (n = 39) sample of Navy pilots who were students or instructors at the Navy's Air Combat Maneuvering Range. Five grades were available for 25 of the 28 students in this sample. These included each of the five topics specified below:

a. The tactics syllabus grade is an average of IP evaluations on 8 ± 2 sorties against a variety of surrogate opponents. The components of the tactics syllabus includes aggressiveness, airmanship, headwork, and tactical maneuvering. These are also separately rated.

b. The aggressiveness rating is based on how well the student stays on the attack.

c. Airmanship is a general category dealing with the basic way of handling the airplane. This includes smooth maneuvering, accurate maintenance of headings, etc.

d. The headwork rating assesses the man's ability to "think on his feet." For example, did the student reach logical conclusions about tactics, fuel usage, and weather.

e. The tactical maneuvering grade is based upon the ability to select and appropriately use various standard maneuvers against the surrogate opponents.

The final overall grade is based upon instrument, bombing, tactics, radar, and carrier qualification grades. The training syllabus upon which that grade is based includes about 110 hours in the plane. A seventh criterion dimension, years flying experience, was available for all 28 students.

Since the range of scores assigned on a four point scale was very limited (e.g., 2.21 to 3.30 for headwork; 2.93 to 3.26 for the final overall grade), the students were rank ordered on each of the six grade scales. Grades in the upper and lower thirds (slight adjustments for tied scores) of each distribution were selected for analysis. The rank ordered raw scores appear in Figure 5.A-1. Correlations between questionnaire responses and each of the sic grade criteria (rank ordered raw scores) were computed. These correlations (phi coefficients) appear in Figure 5.A-2.[1] Also present in Figure 5.A-2 are correlations (phi coefficients) between questionnaire responses and four criteria of instructor versus student group membership. These criteria were, (1) instructors versus the total set of students; (2) instructors versus all students except two who had unusual flying experiences which made them a typical (i.e., a former British Empire Test Pilot School Instructor, and a U.S. test pilot who had flown E2s for some time); (3) instructors versus the eight highest scoring students on the final overall grade; and (4) instructors versus the eight lowest scoring students on the final overall grade.

The 39 pilots completing the Life Experience Inventory formed a rather homogeneous group as all of them, even the students, were rated fighter pilots. Even so, some items distinguished between the various groups. Check marks in Figure 5.A-2 indicate those items with phi values which seem to be statistically significant.

[1]Since deletion of the middle third of the distribution inflates the correlation coefficient, results obtained are only suggestive.

FINAL OVERALL GRADE		TACTICS SYLLABUS GRADE		AGGRESSIVENESS		AIRMANSHIP		HEADWORK		TACTICAL MANEUVERING	
PILOT NO.	VALUE	PILOT NO.	VALUE	PILOT NO.	VALUE	PILOT NO.	VALUE	PILOT NO.	VALUE	PILOT NO.	VALUE
4	3.26	18[3]	3.28	28	3.50	18[3]	3.45	18[3]	3.30	2[1]	3.27
22	3.20	4	3.22	8	3.39	17	3.32	11	3.11	18[3]	3.25
11	3.15	11	3.19	6	3.38	28	3.32	7	3.11	11	3.25
28	3.13	28	3.18	22	3.36	4	3.30	10	3.10	16	3.18
18[3]	3.12	21	3.16	21	3.35	22	3.30	17	3.09	6	3.16
10	3.11	8	3.15	9	3.32	11	3.23	27	3.06	8	3.15
6	3.10	22	3.15	11	3.32	8	3.21	20	3.05	23	3.15
17	3.09	6	3.14	7	3.30	26	3.19	16	3.04	22	3.14
9	3.08	16	3.14	19[4]	3.25	9	3.18	6	3.03	15	3.13
26	3.08	26	3.14	24	3.23	16	3.18	19[4]	3.02	17	3.10
21	3.07	23	3.15	16	3.22	6	3.16	29	3.02	28	3.10
27	3.07	17	3.12	18[3]	3.20	20	3.16	2[1]	3.00	10	3.08
16	3.05	9	3.10	17	3.18	7	3.15	4	3.00	7	3.05
23	3.05	2[1]	3.08	23	3.18	10	3.14	9	3.00	9	3.03
15	3.03	7	3.08	26	3.17	21	3.12	15	3.00	12	3.03
7	3.02	10	3.07	12	3.15	2	3.08	21	3.00	27	3.03
24	3.02	15	3.07	10	3.13	24	3.08	24	3.00	20	2.98
12	3.01	20	3.07	5[2]	3.12	23	3.06	26	3.00	4	2.95
20	3.01	27	3.07	15	3.12	27	3.06	28	3.00	12	2.94
[illegible]	3.00	12	3.02	20	3.10	19[4]	3.05	23	2.93	24	2.88
29	2.97	13	3.02	4	3.09	15	3.04	13	2.92	29	2.85
5[2]	2.95	19[4]	2.99	27	3.08	12	3.00	22	2.91	26	2.84
19[4]	2.93	24	2.94	29	3.07	13	3.00	12	2.90	21	2.81
		5	2.93	13	3.01	29	3.00	5[2]	2.84	5[2]	2.80
		29	2.80	2[1]	3.00	5[2]	2.96	8	2.21	19[4]	2.58

[1]USAF Test Pilot School Graduate, flew E2's 8 years.
[2]Much difficulty in F4 tactics traits training.
[3]British Empire Test Pilot School Instructor.
[4]Flew OV 10's 5 years.
[5]Former VF 121 Tactics Instructors, MIG 21 kill in SEA.

FIGURE 5.A-1 NAVY STUDENT PILOTS RANK ORDERED ON SIX CRITERION DIMENSIONS

Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
1. I like to supervise or direct the actions of others.										
1. Very much	.154	.183	.121	.268	.160	.480	-.302	.160	.265	.447
2. Somewhat	-.198	-.233	-.121	-.268	-.160	-.480	.302	-.160	-.265	-.447
3. Very little										
4. Not at all	.102	.108								
2. *It is important to always be frank* and say what you think.										
1. Strongly agree	✓ .321	.296	✓ .454	.338	-.126	.126	.192	.126	-.056	.354
2. Agree	✓ -.352	✓ -.329	✓ -.454	-.338	.126	-.126	-.192	-.126	.056	-.354
3. No opinion										
4. Disagree	.102	.108								
5. Strongly disagree										
3. Before you entered the Air Force, in what type of house did you and your wife (you and your parents, or you alone) live?										
1. A private, one family house which we owned	-.107	-.093	-.217	-.083	.135	-.405	-.354	-.126	✓ -.609	✓ -.707
2. A private, one family house which we rented	.070	.084	.055	-.201	-.258	.378	-.302	0.0	.436	.447
3. An apartment in a residential apartment house	.070	.036	.215	.215	0.0	.160	✓ .577	.160	.344	.447
4. A condominium which we owned										
4. In your family, how often was the attitude of ignoring pain and withstanding discomfort stressed?										
1. Very often	.024	.036	.055	.215	.160	.378	0.0	.258	.436	.447
2. Often	.027	.020	.012	.012	0.0	-.126	✓ .507	-.289	-.167	0.0
3. Once in a while	.266	.263	✓ .451	.215	-.258	-.258	✓ -.507	.126	-.292	-.333
4. Rarely	✓ -.449	✓ -.441	✓ -.510	-.350	.258	.258		.258		
5. Never	.146	.155						-.258	.236	
5. In sports or games, when you have a compelling lead over your opponent do you tend to ease up?										
1. Very often	-.259	-.256	-.201	-.201						
2. Fairly often	.266	.231	.055	.344	.289	-.405	.447	.258	.245	.302
3. Once in a while	.027	.055	.136	.136	0.0	.405	.169	-.289	.070	-.333
4. Rarely	-.246	-.233	-.121	-.268	-.160	-.160	✓ -.577	0.0	-.311	-.192
5. Never	.024	.036	.055	-.201	-.258	.160	0.0	0.0	-.022	.447
6. *How often did your father, or mother,* or both urge you to equal the accomplishments of your father?										
1. Often	.102	.108	.276		-.258	.258	-.302	.258	.236	.302
2. Regularly	.212	.226		.276	.258	.160	-.447	0.0	-.022	.192
3. Once in a while	.013	.035	-.179	.109	.289	.160	.302	-.160	.091	0.0
4. Rarely	-.004	-.089	.083	.083	0.0	0.0	0.0	0.0	.127	-.192
5. Never	-.172	-.148	-.045	-.295	-.258	-.378	.333	0.0	-.290	-.192

[1]Students versus Instructors

FIGURE 5.A-2. PHI COEFFICIENTS FOR TEN CRITERION DIMENSIONS

Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
7. How often do you seek advice and aid from other people?										
1. Very often	.024	.036	.344	-.201	-.480	-.258	-.302	-.480	-.387	-.447
2. Often	-.207	-.186	-.295	-.430	-.160	-.258	-.167	0.0	-.426	-.192
3. Once in a while	.091	.055	.012	.258	.250	.500	.192	.258	✓ .653	.507
4. Rarely	.181	.193		.402	.378	-.258	.192	.258	-.022	
5. Never										
8. How frequently has the thought entered your mind that other people dislike you or something about you?										
1. Very often	.102	.108	.276		-.258	.258	-.302	.258	.236	.302
2. Fairly often	240	.257	.276	✓ .508	.289	✓ .577	.192	.160	.344	.447
3. Once in a while	.023	.004	-.109	-.109	0.0	✓ -.516	0.0	-.135	-.245	-.354
4. Never	✓-.352	✓ -.345	-.179	-.369	-.258	-.258		-.258	-.265	-.302
9. It doesn't matter whether you win or lose; it's how you play the game										
1. Strongly agree										
2. Agree	-.101	-.089	.083	-.077	-.160	.378	0.0	-.258	-.022	-.302
3. No opinion	.146	.155		.276	.258	.258	.302	.258	.236	.302
4. Disagree	-.027	-.055	-.136	-.012	.126	-.250	.354	0.0	-.056	0.0
5. Strongly disagree	.036	.054	.083	-.077	-.160	-.135	✓ -.507	0.0	-.044	0.0
10. In general, divorce settlements are too favorable to the woman.										
1. Strongly agree	-.288	-.268	-.136	✓ -.511	-.405	.135	.169	.126	.070	.192
2. Agree	.027	.020	.012	.012	0.0	0.0	-.302	-.258	-.167	-.169
3. No opinion	.267	.257	.276	✓ .508	.289	-.160	-.169	.160	-.033	0.0
4. Disagree	.146	.155		.276	.258		.302		.236	
5. Strongly disagree										
11. To get into the fighter pilot program it is excusable to conceal potential major physical disabilities such as diabetes or a heart murmur.										
1. Strongly agree	.102	.108	.276		-.258	.258	-.302	.258	.236	.302
2. Agree	-.049	-.035	-.293	-.077	.258	-.160	-.447	0.0	-.033	0.0
3. No opinion	.070	-.023	.055	.055	0.0	-.378	.447	.160	-.182	0.0
4. Disagree	.144	.176	.233	.233	0.0	0.0	0.0	-.378	-.044	-.333
5. Strongly disagree	-.199	-.181	-.209	-.209	0.0	.289	.192	.160	.127	.302
12. Being self-assured and confident (cocky) is acceptable if a person can back it up.										
1. Strongly agree	.109	.126	.215	.055	-.160	0.0	-.192	-.160	-.022	.192
2. Agree	-.113	-.142	-.233	-.109	.126	-.126	-.333	.135	-.091	-.354
3. No opinion	-.113	-.106	-.201	.055	.258	.258	.302	.258	.236	.302
4. Disagree	.024	.036	.055	-.201	-.258	0.0	.447	-.258	-.265	
5. Strongly disagree	.146	.155	.276	.276	0.0	0.0			.236	
13. The saying "when the going gets tough the tough get going," applies to air combat even more than football.										
1. Strongly agree	.024	.029	-.295	.209	✓ .500	-.258	0.0	✓ .500	-.203	-.169
2. Agree	.073	.054	.217	.083	-.135	.160	0.0	-.405	.127	.169
3. No opinion	-.049	-.035	.083	-.293	-.378	.378	0.0	0.0	.344	.302
4. Disagree	-.113	-.106	.055	-.201	-.258	-.258		-.258	-.265	-.302
5. Strongly disagree										

FIGURE 5.A-2 (Continued)

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Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
14. I like to tell other people what I think of them.										
1. Very much	.109	.126	✓ .459	-.201	✓ -.577	-.378	-.447	✓ -.577	✓ -.588	✓ -.707
2. Somewhat	.206	.176	-.025	.233	.258	-.126	0.0	✓ .500	.310	✓ .667
3. Very little	.013	.035	-.025	.233	.258	✓ .577	.192	0.0	.350	0.0
4. Not at all	✓ -.441	✓ -.435	-.440	-.440		-.258	.302		-.265	
15. Sometimes in combat your own command and control can be your worst enemy.										
1. Strongly agree	-.114	.094	-.268	.012	.289	.480	-.192	.480	✓ .609	✓ .577
2. Agree	.171	.198	-.077	.083	.160	-.258	0.0	-.289	-.408	-.192
3. No opinion	.267	.226	.402	✓ .508	.135	0.0	.447	.258	.127	0.0
4. Disagree	-.198	-.183	.136	-.440	✓ -.577	-.160	-.192	-.480	-.387	-.447
5. Strongly disagree	-.259	-.256	-.201	-.201						
16. One should be aware of the current fads and fashions in clothing.										
1. Strongly agree										
2. Agree	-.024	.006	-.209	.045	.258	.289	-.169	.250	.310	.192
3. No opinion	.107	.054	-.077	.217	.289	-.258	✓ .577	0.0	-.167	.192
4. Disagree	-.114	-.094	.136	-.268	-.405	-.135	-.192	-.480	-.311	-.507
5. Strongly disagree	.102	.108	.276		-.258	.258	-.302	.258	.236	.302
17. Poor discipline on the ground leads to poor performance in the air.										
1. Strongly agree	.059	.090	.136	-.121	-.258	0.0	0.0	.135	-.167	0.0
2. Agree	.027	.020	.012	.258	.250	0.0	-.0	.310	.310	.169
3. No opinion	.102	.108				-.258	.302		-.265	
4. Disagree	-.049	-.089	-.077	-.077	0.0	-.258	-.192	-.160	-.033	-.192
5. Strongly disagree	-.259	-.256	-.201	-.201						
18. I like to be asked to settle disputes between others.										
1. Very much	.181	.193	.276	.276	0.0	0.0	-.302	-.258	-.022	0.0
2. Somewhat	✓ .334	✓ .387	.352	.352	0.0	.135	-.169	-.135	-.070	-.169
3. Very little	✓ -.545	✓ -.664	✓ -.651	✓ -.511	.258	-.258	.302	.378	.236	.302
4. Not at all	.070	.084	.215	.055	-.160	0.0	.192	0.0	-.033	0.0
19. When did you first get interested in being a fighter pilot?										
1. In grade school	-.073	-.077	-.169	.080	.250	-.250	.333	0.0	.290	.169
2. In high school	-.023	-.045	-.179	.109	.289	.135	-.192	.405	-.033	0.0
3. In college	.109	.126	.215	-.201	-.378	-.258	-.302	-.160	-.265	-.302
4. In undergraduate pilot training	.024	.036	.215	-.201	-.378	.378	0.0	-.378	-.265	0.0
20. One should abandon an activity that he enjoys if friends criticize it.										
1. Strongly agree										
2. Agree										
3. No opinion										
4. Disagree	.081	.107	-.025	-.025	0.0	.135	0.0	-.289	-.167	-.192
5. Strongly disagree	-.081	-.107	.025	.025	0.0	-.135	0.0	.289	.167	.192

FIGURE 5.A-2 (Continued)

Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
21. How often do you make use of credit or loans of over 30 days?										
1. Never	.293	.314	✓ .508		-.480	0.0	✓ -.577	-.135	-.135	0.0
2. Rarely	-.090	-.102	-.209	.295	✓ .500	.378	.333	.258	.450	.169
3. Once in a while	.107	.130	.083	-.077	-.160	-.378	.192	-.160	-.290	-.447
4. Fairly often	✓ -.461	✓ -.457	-.369	-.369						
5. Often	.024	-.023	.055	.055	0.0	-.160		0.0	.236	.302
22. I like to do things my own way, regardless of criticism or convention.										
1. Very much	.237	.210	.109	✓ .472	.378	.378	-.169	✓ .516	.181	.507
2. Somewhat	✓ -.334	-.313	-.233	✓ -.596	-.405	-.405	0.0	✓ -.516	-.169	-.354
3. Very little	.146	.155	.276	.276	0.0	.258	.447		.236	
4. Not at all	.102	.108				-.258	-.302		-.265	-.302
23. In a combat situation the saying, "When your number is up you've had it," has a lot of truth in it.										
1. Strongly agree	-.259	-.256	-.201	-.201						
2. Agree	-.033	-.023	.055	-.201	-.258	-.378	-.302	-.258	-.387	-.302
3. No opinion	.146	.108		.402	.378	.258	.302	.258	.344	.302
4. Disagree	.125	.181	.209	.080	-.135	.135	.354	-.258	.290	.192
5. Strongly disagree	-.105	-.139	-.179	-.179	0.0	0.0	-.447	.289	-.387	-.302
24. While you were growing up, how often did your family get into conflicts with close relatives?										
1. Very often										
2. Often	.024	-.023	-.201	.055	.258	-.378	.302	.258	-.022	
3. Once in a while	-.105	-.089	-.179	-.179	0.0	.378	-.302	-.160	-.022	.192
4. Rarely	-.024	-.029	.045	-.080	-.126	.258	✓ -.507	.378	-.056	0.0
5. Never	.107	.130	.217	.217	0.0	-.258	✓ .577	-.405	.091	-.192
25. How difficult for you were changes from one school or college to another?										
1. Difficult and disagreeable	-.259	-.256	-.201	-.201						
2. Somewhat difficult and disagreeable	.177	.163	.055	.215	.160	0.0	-.354	.480	.245	.192
3. Easily enough made	-.006	.020	-.121	.136	.258	.289	.192	.126	.203	-.192
4. Fun	.073	.093	.338	-.293	✓-.577	-.405	-.447	✓ -.674	✓ -.588	-.354
5. I did not make these kinds of changes	-.152	-.195	-.179	-.025	.160	.160	✓ .577	.258	.127	.447
26. It is very important to be successful in things you try to do.										
1. Strongly agree	.090	.065	.080	.080	-.0	-.258	.192	.135	.044	.192
2. Agree	-.040	-.017	.012	.012	0.0	.258	-.192	-.135	-.044	-.192
3. No opinion	.102	.108								
4. Disagree	-.259	-.256	-.201	-.201						
5. Strongly disagree										

FIGURE 5.A-2 (Continued)

	Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Maneuvering	Airmanship	Tactics Syllabus Grades
27.	As a boy, how frequently did you take a dare?										
	1. Almost always	.109	.084	-.201	.344	.480	-.160	.447	0.0	.245	.447
	2. Usually	-.284	-.270	-.350	-.350	0.0	.160	-.447	0.0	✓ -.491	-.192
	3. Sometimes and sometimes not	.187	.195	.382	.136	-.258	0.0	0.0	-.126	.181	-.333
	4. Almost never	-.033	-.023	.055	-.201	-.258	0.0	0.0	.258	-.022	.302
	5. Never										
28.	The difference between the combat effective pilot with no kills and a few kills is often a matter of luck.										
	1. Strongly agree	.113	.107	-.025	.352	.378	✓ .630	-.333	.378	.292	✓ .707
	2. Agree	-.269	-.278	-.352	✓ -.472	-.135	✓ -.630	.192	-.126	-.290	-.447
	3. No opinion										
	4. Disagree	.212	.226	✓ .508	.276	-.289	0.0	.192	.378	-.022	-.447
	5. Strongly disagree	.102	.108								
29.	A good pilot will spend as many hours as he can practicing dry runs to assure complete mastery of all aircraft functions.										
	1. Strongly agree	.009	.006	.045	.045	0.0	.126	0.0	.126	.181	.169
	2. Agree	-.056	-.065	.045	-.350	-.405	-.289	0.0	-.135	✓ -.537	-.507
	3. No opinion	-.259	-.256	-.201	-.201						
	4. Disagree	.212	.226		✓ .508	.480	.160	0.0	0.0	.436	.447
	5. Strongly disagree										
30.	As a child (under 12) I:										
	1. Had few or no fights	-.237	-.210	-.109	-.352	-.250	.126	.169	✓ -.500	.181	-.169
	2. Had several fights	.144	.142	-.025	.109	.135	-.250	-.333	.405	-.169	.169
	3. Fought frequently	.181	.155	.276	.402	.160	.258	.302	.160	-.022	0.0
31.	In fights that you have been in, were your opponents:										
	1. From the same neighborhood	.198	.183	.121	.268	.160	-.289	.302	.160	-.344	-.447
	2. From across town	-.101	-.089	-.077	-.293	-.258	.378	-.302	0.0	.236	.447
	3. From another town	-.113	-.106	.055	-.201	-.258	-.258		-.258		
	4. This does not apply since I never fought.	-.113	-.106	-.201	.055	.258	.258			.236	
32.	While you were in high school, how old were most of your closest friends in relation to your age?										
	1. About my own age	-.145	-.126	-.055	-.055	0.0	.160	-.192	.160	.182	-.192
	2. Greater than my own age	.070	.036	.055	.055	0.0	0.0	0.0	-.160	-.022	.192
	3. Less than my own age	.102	.108								
	4. Varied greatly	.102	.108				-.258	.302		-.265	
33.	It is understandable why the Japanese Kamakazi pilots performed as they did.										
	1. Strongly agree	.070	.084	.055	-.201	-.258	.160	-.302	0.0	-.022	.447
	2. Agree	-.172	-.148	-.169	-.295	-.135	-.135	.192	-.135	-.044	-.169
	3. No opinion	-.113	-.106	.055	-.201	-.258			-.258	-.265	-.302
	4. Disagree	.171	.130	.083	.338	.258	.258	-.333	.378	.070	.0
	5. Strongly disagree	.024	.036	.055	.215	.160	-.378	.447	-.258	.236	

FIGURE 5.A-2 (Continued)

Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
34. The things learned in college have little relationship to being a good fighter pilot.										
1. Strongly agree	-.105	-.089	-.179	-.025	.160	.480	-.302	-.160	.127	.354
2. Agree	-.161	-.141	-.350	-.209	.160	-.289	.192	.135	-.044	0.0
3. No opinion										
4. Disagree	.175	.142	.352	.233	-.126	.126	-.169	.126	.070	-.333
5. Strongly disagree	.146	.155	.276		-.258	-.378	.302	-.258	-.265	
35. Have you been ejected from the Officer's Club?										
1. Several times										
2. A few times										
3. Once or twice	.036	.012	-.077	.083	.160	.160	-.192	.289	.350	✓ .577
4. Never	-.036	-.012	.077	-.083	-.160	-.160	.192	-.289	-.350	✓ -.577
36. When you were in school, how much did you help other students with their studies?										
1. Very much	-.101	-.089	.083	-.293	-.378	0.0	.302	-.258		
2. Some	.220	.195	.136	.258	.126	-.250	-.169	.258	-.350	-.507
3. Very little	-.062	-.045	-.025	.109	.135	.135	0.0	0.0	.350	.354
4. Not at all	-.164	-.154	-.293	-.293		.258		-.258		.302
37. As a child, whenever my friends couldn't decide what to do, I usually could come up with good suggestions.										
1. Very often	.024	-.023	-.201	.215	.378	.258	.302	.160	.344	.302
2. Often	-.091	-.055	-.136	-.258	-.126	-.258	-.333	-.378	-.417	✓ -.667
3. Once in a while	.081	.072	.233	.109	-.126	.126	.169	.258	.203	.507
4. Rarely										
5. Never										
38. How old were you when your parents first left you alone or in charge of younger siblings?										
1. 8 or less	.212	.226	.402	.276	-.160	.160	-.192	0.0	-.182	0.0
2. 9 or 10	-.240	-.270	-.350	-.209	.160	-.135	0.0	.378	.127	.302
3. 11 or 12	.206	.210	.233	.352	.126	.126	.169	-.258	-.070	-.192
4. 13 or 14	-.049	-.035	-.077	-.293	-.258	-.258		0.0	.236	
5. 15 or over	-.259	-.256	-.201	-.201						
39. The essence of air to air combat is a man on man, individual effort.										
1. Strongly agree	-.056	-.065	-.080	-.080	0.0	-.126	-.333	.378	-.292	-.169
2. Agree	-.006	-.017	-.121	.258	.378	✓ .516	.354	0.0	✓ .523	.507
3. No opinion										
4. Disagree	.212	.226	.402		-.378	-.258	-.302	-.289	.127	-.302
5. Strongly disagree	-.101	-.089	-.077	-.293	-.258	-.378	.202	-.258	-.387	-.302
40. Doing minor mechanical or electrical repairs can be enjoyable.										
1. Strongly agree	.041	.077	-.209	.169	.378	.378	-.333	.378	.181	.169
2. Agree	-.024	-.065	.295	-.209	✓ -.500	✓ -.500	.169	✓ -.500	-.292	-.333
3. No opinion	.146	.155		.276	.258	.258	.302	.258	.236	.302
4. Disagree	-.259	-.256	-.201	-.201						
5. Strongly disagree										

FIGURE 5.A-2 (Continued)

Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
41. Have you found yourself in a situation where you just didn't know what to do?										
1. Very often	.102	.108		.276	.258	.258	.302	.258	.236	.302
2. Often	.102	.108		.276	.258	.258	-.302	.258	.236	.302
3. Once in a while	.171	.164	.217	.083	-.135	.160	.192	-.289	.245	-.192
4. Rarely	✓ -.321	✓ -.329	✓ -.454	-.338	.126	-.258	0.0	.250	-.181	.169
5. Never	.181	.193	.402		-.378	-.258	-.302	-.378	-.387	-.447
42. Top notch fighter pilots have so strong an urge to fly it is difficult for nonflyers to understand.										
1. Strongly agree	-.123	-.160	-.136	-.136	0.0	-.250	-.169	.378	-.070	.169
2. Agree	.113	.142	.233	-.025	-.258	0.0	0.0	✓ -.516	-.167	-.354
3. No opinion	-.113	-.106	-.201	.055	.258	.258	.302	.258	.236	.302
4. Disagree	.146	.155		.276	.258	.258			.236	
5. Strongly disagree										
43. It is important to have your work organized and planned before starting it.										
1. Strongly agree	-.006	.020	.382	-.268	✓ -.630	.135	✓ -.354	-.258	-.290	-.507
2. Agree	.123	.090	-.268	.258	✓ .516	.126	✓ .507	.250	.292	.507
3. No opinion	.146	.155	.276	.276	0.0	0.0	-.302	0.0	.236	.302
4. Disagree	-.271	-.262	-.369	-.179	.258	-.378	0.0		-.265	-.302
5. Strongly disagree										
44. It's not important if you are the very best in a field as long as you are doing the best you can.										
1. Strongly agree	-.062	-.045	.233	-.179	-.405	0.0	.192	-.160	.127	0.0
2. Agree	-.076	-.137	-.121	.012	.135	.160	-.354	.258	.091	.169
3. No opinion										
4. Disagree	.091	.125	-.268	.136	.405	0.0	.354	0.0	-.056	0.0
5. Strongly disagree	.102	.108	.276		-.258	-.258	-.302	-.258	-.265	-.302
45. Mastering the flying techniques was the easiest part of the training program.										
1. Strongly agree	.070	.084	.055	-.201	-.258	0.0				
2. Agree	-.187	-.160	-.382	.121	✓ .500	-.126	✓ .507	-.378		.302
3. No opinion	-.164	-.240	-.077	-.293	-.258	0.0	-.302	-.135	-.070	-.169
4. Disagree	.266	.263	✓ .459	.215	-.258	.160	-.333	.378	.236	.302
5. Strongly disagree								.126	-.044	-.169
46. How old were you when you owned your first car or motorcycle?										
1. 16 or younger	.013	.035	-.025	-.179	-.160	-.160	-.192	✓ -.577	-.167	-.354
2. 17-18	-.154	-.183	-.268	.012	.289	.160	-.192	✓ .516	.245	.447
3. 19-20	.013	-.004	.109	.109	0.0	.135	.354	0.0	.127	0.0
4. 21 or over	.145	.163	.215	.055	-.160	-.135	0.0	0.0	-.167	0.0

FIGURE 5.A-2 (Continued)

Question	All Pilots	All Pilots[1] Except 2 & 18	Worst Overall[1] vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
47. You should conform to custom and avoid doing things people you respect consider unconventional.										
1. Strongly agree	-.033	-.023	.055	-.201	-.258	-.258	-.302	0.0	-.022	-.302
2. Agree	-.247	-.240	-.077	-.293	-.258	-.258		-.258		
3. No opinion	.006	.017	-.136	.121	.258	.405	.169	-.126	.044	0.0
4. Disagree	.177	.163	.215	.215	0.0	-.160	0.0	.289	-.033	.192
5. Strongly disagree										
48. How frequently do you borrow money from personal friends?										
1. Very often	-.076	-.137	-.268	.012	.289	.289	.192	.405	✓ .609	✓ .707
2. Fairly often	.123	.160	.258	.012	-.250	0.0	.169	-.250	-.290	-.169
3. Once in a while	-.062	-.045	-.025	-.025	0.0	-.289	-.354	-.160	-.290	✓ -.577
4. Rarely										
5. Never										
49. People in authority are often deserving of criticism.										
1. Strongly agree	-.049	-.035	-.077	-.077	0.0	0.0	0.0	0.0	-.182	0.0
2. Agree	.040	.017	-.012	.121	.135	0.0	-.354	.160	.167	.192
3. No opinion	-.113	-.106	.055	-.201	-.258			-.258		-.302
4. Disagree	.212	.226	.276	.276	0.0	0.0	.447		-.022	
5. Strongly disagree	-.259	-.256	-.201	-.201						
50. Off-duty time for officers should be completely their own.										
1. Strongly agree	-.155	-.160	-.136	-.012	.126	.250	0.0	.378	.056	0.0
2. Agree	.081	.107	.109	-.025	-.135	-.126	0.0	-.405	-.044	.192
3. No opinion	-.259	-.256	-.201	-.201						
4. Disagree	.240	.226	.276	.276	0.0	-.258	0.0	0.0	-.022	-.192
5. Strongly disagree										
51. Before important exams I tend to:										
1. Study very hard	.106	.077	.169	-.080	-.250	-.250	-.333	.135	.044	0.0
2. Be a little uptight	-.076	-.055	-.268	.136	.405	.405	0.0	0.0	.245	.192
3. Have physical reactions, e.g., knots in the stomach										
4. Say "to hell with it" and go drinking										
5. Stay relaxed and take it in stride	-.049	-.035	.083	-.077	-.160	-.160	.354	-.258	-.387	-.302
52. Before you were married, when you dated one girl fairly regularly, did you date other girls at the same time?										
1. Very often	-.247	✓ -.368	-.293	-.077	.258		.302	.258	.236	.302
2. Often	-.152	-.139	-.025	-.369	-.378	-.258	-.302	-.378	✓ -.491	-.447
3. Once in a while	.113	.107	-.025	.233	.258	-.250	-.169	.135	-.044	0.0
4. Rarely	.013	.035	-.025	-.025	0.0	.405	0.0	.135	.350	.447
5. Never	.212	.226	.402	.276	-.160	0.0	.302	-.160	-.022	-.192

FIGURE 5.A-2 (Continued)

Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
53. How many fights did you have from age 18 or older?										
1. 0	-.090	-.065	-.080	-.080	0.0	.135	0.0	.135	-.044	-.302
2. 1 or 2	.091	.055	.012	.258	.250	-.250	.333	0.0	.181	.169
3. 3 to 5	.181	.193	.276		.250	.378	-.302	0.0	.236	.447
4. 5 to 10	-.247	-.240	-.293	-.293		-.258	-.302		-.265	-.302
5. More than 10	.102	.108	.276		-.258			-.258	-.265	-.302
54. It bothers me to lose a game.								✓ -.500	.056	-.169
1. Very much	.123	.160	.258	.012	-.250	-.126	-.169	✓ .500	-.056	.169
2. Somewhat	-.155	-.195	-.382	-.012	.378	0.0	0.0			
3. Very little	.102	.108	.276		-.258	.258	.302			
4. Not at all										
55. Responsibility for birth control rests with the woman.										
1. Strongly agree	.024	.036	.055	.055	0.0	.258		-.258	-.022	0.0
2. Agree	-.114	-.094	-.268	.012	.289	.135	.192	-.135	.127	.192
3. No opinion	-.247	-.240	-.293	-.077	.258	.258	-.302	.258	.236	.302
4. Disagree	.027	-.017	.012	-.121	-.135	-.405	.169	.135	-.408	-.354
5. Strongly disagree	.267	.286	✓ .508	.276	-.289	0.0	-.302	0.0	.245	0.0
56. While you were growing up, how often did your mother scold you?										
1. Very often	-.113	-.106	-.201	-.201		.258		-.258		.302
2. Often	-.024	-.029	.169	-.080	-.250	.258	0.0	-.126	-.056	0.0
3. Once in a while	.144	.142	-.025	.233	.258	-.250	-.169	.378	.056	0.0
4. Rarely	-.101	-.089	-.077	-.077	0.0	-.250	.302	-.258		-.302
5. Never										
57. Sports like auto racing are not too dangerous if you have the skill.										
1. Strongly agree	.267	.286	✓ .508	.276	-.289	0.0	✓ -.507	0.0	-.290	0.0
2. Agree	-.172	-.186	-.169	-.295	-.135	0.0	.302	0.0	-.033	0.0
3. No opinion	-.113	-.106	-.201	-.201				0.0		
4. Disagree	-.154	-.183	-.268	.136	.405	0.0	✓ .707	0.0	.350	.192
5. Strongly disagree	.240	.257	.276	.276	0.0	0.0	-.447		-.022	-.192
58. A person should only play when there is a good chance of winning.										
1. Strongly agree	.146	.155	.402		-.378	0.0	-.447	0.0	-.022	0.0
2. Agree	-.033	-.023	.055	.055	0.0	.258		-.258	.236	0.0
3. No opinion										
4. Disagree	.023	.045	-.233	.179	.405	.135	.447	.135	.033	.169
5. Strongly disagree	-.101	-.154	-.077	-.293	-.258	-.378		0.0	-.265	-.302
59. How old were you when you had your first regular paid job, part-time or full time?										
1. 12 years or less	.145	.163	.055	.055	0.0	.480	0.0	.289	.436	✓ .577
2. 13 to 15	-.041	-.077	.209	-.045	-.258	✓ -.630	.169	-.250	-.417	✓ -.667
3. 16 to 18	-.076	-.055	-.268	.012	.289	.289	-.192	0.0	.091	.192
4. 19 or older										

FIGURE 5.A-2 (Continued)

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Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
60. When involved in making group decisions, the group will usually agree with my opinion.										
1. Very often	.181	.193	.276	.276	0.0	.258		-.258	.236	-.302
2. Often	-.145	-.163	-.344	-.055	.289	-.460	0.0	0.0	-.344	0.0
3. Once in a while	.024	.036	.215	-.201	-.378	.378	0.0	.258	.236	.302
4. Rarely										
5. Never										
61. The flying segments of training were the most enjoyable parts of the program.										
1. Strongly agree	.049	.089	-.083	.077	.160	-.258	-.447	0.0	.022	0.0
2. Agree	-.101	-.154	-.077	-.077	0.0		.302	0.0	-.022	0.0
3. No opinion	.102	.108	.276		-.258	.258	.302			
4. Disagree										
5. Strongly disagree										
62. To what extent did your father or mother stress the importance of getting ahead in the world?										
1. Very often	-.004	.012	.083	-.077	-.160	0.0	.302	-.480	-.182	-.192
2. Fairly often	.081	.072	.233	-.179	-.405	-.258	✓ -1.000	.126	-.408	-.333
3. Once in a while	-.006	-.017	-.121	.382	✓ .500	.250	✓ .845	.135	.450	✓ .577
4. Rarely	-.101	-.089	-.293	-.293				.258	.236	
5. Never										
53. The best leaders only emerge when the situation demands it.										
1. Strongly agree	-.049	-.035	.083	.083	0.0	-.160	0.0	0.0	.127	0.0
2. Agree	.047	.035	-.025	.109	.135	✓ .516	0.0	0.0	.350	.507
3. No opinion	.109	.126	.215	-.201	-.378	-.378	.302	-.378	✓ -.491	-.447
4. Disagree	-.125	-.141	-.350	-.080	.289	-.135	-.192	.405	-.044	0.0
5. Strongly disagree	.102	.108	.276		-.258			-.258		-.302
64. Generally, what do you think is the appropriate punishment for a bank *robber who has murdered someone in the* course of a robbery?										
1. Capital punishment	-.171	-.198	-.217	-.217	0.0	-.258	.354	-.135	.167	0.0
2. Life imprisonment without parole	.177	.198	.055	.215	.160	.289	-.192	.480	-.182	.302
3. Life imprisonment with *parole*										
4. A prison term										
5. Sentencing should depend on the individual circumstances of the crime	.024	.036	.215	.055	-.160	0.0	-.302	.378	-.022	-.302
65. *Flying with your head is as important* as flying with your hands, e.g., having the coordination skills needed to fly well.										
1. Strongly agree	.105	.089	.025	.369	.378	0.0	.302	✓ .577	.182	.192
2. Agree	-.105	-.089	-.025	-.369	-.378	0.0	-.302	✓ -.577	-.182	-.192
3. No opinion										
4. Disagree										
5. Strongly disagree										

FIGURE 5.A-2 (Continued)

	Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
66.	A fighter pilot will live or die on the basis of his own competence.										
	1. Strongly agree	✓ -.368	✓ -.387	-.352	✓ -.472	-.135	.135	-.192	.258	-.167	-.192
	2. Agree	.269	.278	.352	.233	-.126	0.0	0.0	-.378	.169	0.0
	3. No opinion										
	4. Disagree	.146	.155		.276	.258	-.378	.447		-.265	
	5. Strongly disagree	.102	.108		.276	.258	.258	-.302	.258	.236	.302
67.	To what extent do you think your mother or father emphasized the importance of improving the position of the family?										
	1. A great extent	-.113	-.106	-.201	-.201		.258	-.192	-.258		.302
	2. A moderate extent	.081	.072	-.025	.109	.135	-.126	.169	0.0	-.044	-.169
	3. A small extent	-.040	-.017	.258	-.121	-.378	0.0	0.0	-.135	-.311	-.192
	4. Almost to no extent	.013	-.004	-.179	.109	.289	0.0		.258	.310	.192
68.	Anyone who is willing to work hard has a good chance of succeeding.										
	1. Strongly agree	.006	.017	-.012	-.136	-.126	-.258	-.333	.258	-.181	-.169
	2. Agree	-.006	-.017	.012	.136	.126	.258	.333	-.258	.181	.169
	3. No opinion										
	4. Disagree										
	5. Strongly disagree										
69.	When serving on a committee I like to be in charge.										
	1. Very much	.175	.176	-.179	.109	.289	-.126	-.169	.126	-.181	0.0
	2. Somewhat	-.123	-.125	.121	-.012	-.135	.250	.169	0.0	.310	.169
	3. Very little	-.113	-.106	.055	-.201	-.258	-.258		-.258	-.265	-.302
	4. Not at all										
70.	In a combat situation, only he is lost who gives himself up for lost.										
	1. Strongly agree	.024	.055	.136	.012	-.126	.126	-.192	.126	.070	0.0
	2. Agree	.206	.176	.109	.352	.250	0.0	.192	.126	-.056	.169
	3. No opinion	-.033	-.023	.055	-.201	-.258	-.258		-.378	-.022	-.302
	4. Disagree	✓ -.352	✓ -.345	-.369	-.369						
	5. Strongly disagree										
71.	When not feeling well one should try to go to work anyway.										
	1. Strongly agree	.293	.314	.402	.402	0.0	-.289	-.354	-.160	-.426	-.354
	2. Agree	.106	.077	-.080	.169	.250	.258	✓ .507	.378	✓ .648	✓ .845
	3. No opinion	-.033	-.023	.055	-.201	-.258	-.258		-.258	-.265	-.302
	4. Disagree	✓ -.387	✓ -.377	-.209	-.350	-.160	.258	-.302	-.160	-.265	-.447
	5. Strongly disagree										
72.	During actual combat a good pilot is likely to be:										
	1. Calm throughout the combat mission	.146	.155	.402		-.378	-.258	-.302	-.378	-.387	-.447
	2. Somewhat nervous before and calm during combat	.140	.164	-.077	-.077	0.0	-.135	-.447	-.135	-.311	0.0
	3. Tense and alert at all times	-.237	-.278	✓ -.472	.025	✓ .500	.126	✓ .667	✓ .516	✓ .653	.507
	4. Apprehensive but doing his best despite it	.070	.084	.344	.055	-.289	.160	-.192	-.160	-.182	-.192

FIGURE 5.A-2 (Continued)

Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
73. When in a group I like to accept the leadership of someone I respect and admire.										
1. Very much	-.207	-.224	-.169	-.295	-.135	.126	0.0	0.0	.245	.354
2. Somewhat	.106	.112	.169	.295	.135	-.126	0.0	0.0	-.450	-.354
3. Very little	.181	.193						0.0	.344	
4. Not at all										
74. As a youth (12 to 17) I:										
1. Had few or no fights	-.047	.044	.025	-.109	-.135	.135	-.169	-.405	-.091	-.169
2. Had several fights	-.023	-.045	-.179	-.025	.160	-.135	0.0	.480	.127	.192
3. Fought frequently	.146	.108	.276	.276	0.0	-.135	.302	0.0	-.022	0.0
75. It is often better to give in and avoid a fight than to try to have things your own way.										
1. Strongly agree										
2. Agree	.047	.035	-.025	.233	.258	-.405	.169	0.0	.091	0.0
3. No opinion	-.199	-.224	.045	-.350	-.405	.135	0.0	.258	.091	0.0
4. Disagree	.144	.176	-.025	.109	.135	.258	-.192	-.258	-.169	0.0
5. Strongly disagree										
76. In general the U.S. justice system is soft on criminals.										
1. Strongly agree	-.009	.029	.080	-.169	-.250	-.126	-.333	-.126	.044	-.169
2. Agree	.059	.020	-.121	.258	.378	0.0	.169	.126	-.044	.169
3. No opinion										
4. Disagree	-.113	-.106	.055	-.201	-.258	.258	.302			
5. Strongly disagree										
77. In male-female relationships the woman should never be aggressive.										
1. Strongly agree										
2. Agree	.102			.276	.258		.302	.258	.236	.302
3. No opinion										
4. Disagree	-.177	-.163	-.344	-.215	.135	.160	-.192	.135	.033	0.0
5. Strongly disagree	.145	.163	.344	.055	-.289	-.160	0.0	-.289	-.182	-.192
78. Would you pick up a service man in uniform who was hitchhiking?										
1. Very often	.238	.231	.215	.344	.135	.289	0.0	0.0	-.044	.333
2. Often	.047	.035	-.179	-.025	.160	-.405	-.192	.135	.091	-.192
3. Once in a while	-.114	-.094	.136	-.121	-.258	.405	-.192	0.0	-.033	-.192
4. Rarely	✓ -.352	✓ -.345	-.369	-.369		-.258	.302		-.265	
5. Never	.146	.155	.276	.276	0.0	-.258	.302	-.258	.236	
79. *A man's devotion to flying must be* tempered by his devotion to his family.										
1. Strongly agree	.036	.054	.083	-.077	-.160	.378	-.192	0.0	-.022	0.0
2. Agree	-.024	-.065	-.209	.045	.258	-.250	0.0	✓ .500	-.056	0.0
3. No opinion	-.033	-.023	.055	-.201	-.258	.258		-.378		0.0
4. Disagree	-.062	-.045	-.179	.109	.289	-.160	✓ .577	-.378	.091	0.0
5. Strongly disagree	.146	.155	.402		-.378	0.0	-.447	0.0	-.022	0.0

FIGURE 5.A-2 (Continued)

	Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
80.	How many times did your family move from one city or town to another because your father was seeking a better opportunity?										
	1. Never	-.106	-.077	-.045	-.045	0.0	-.258	-.169	✓ -.516	-.181	-.507
	2. Once	-.004	.012	.083	-.077	-.160	.378	-.447	.160	.127	.192
	3. Twice	-.101	-.154	-.293	-.077	.258	0.0	0.0	0.0	-.022	.192
	4. Three times	.070	.036	-.201	.055	.258	-.160	.447	.378	-.022	.302
	5. Four or more times	.212	.226	.402	.276	-.160	.160	.302	.160	.236	
81.	After a serious fight or argument I:										
	1. Calm down quickly	-.220	-.231	-.136	-.382	-.258	-.258	0.0	-.378	-.408	-.169
	2. Feel weak and shaky	.102	.108								
	3. Do not think about the incident much	-.247	-.240	-.077	-.293	-.258		-.302	-.258	-.265	-.302
	4. Have difficulty falling asleep										
	5. Keep going over what I should have done or said in my mind	✓ .321	✓ .329	.217	.568	.378	.258	.169	✓ .500	✓ .528	.333
82.	I like to argue against points of view different from mine.										
	1. Very much	✓ .378	✓ .355	.344	✓ .567	.250	0.0	-.333	.258	.056	0.0
	2. Somewhat	-.073	-.042	-.045	-.169	-.126	-.126	✓ .507	-.405	-.169	-.169
	3. Very little	✓ -.441	✓ -.435	-.268	-.440	-.258	.258	-.302	.258	.236	.302
	4. Not at all										
83.	When you lived with your parents, whose ideas were accepted?										
	1. My mother usually	-.033	-.023	.055	-.201	-.258	-.258		-.258		
	2. My father usually	.155	.160	.012	.258	.250	.250	-.169	.250	.408	0.0
	3. My mother and father about the same	-.125	-.102	-.080	-.209	-.135	-.258	-.169	-.258	-.537	-.169
	4. I cannot say	-.033	-.106	.055	.055	0.0	.258	.447	.258	.236	.302
84.	When you were growing up, how often did your father scold you?										
	1. Very often	.102	.108	.276		-.258			-.258	-.265	-.302
	2. Fairly often	-.023	-.045	-.179	-.025	.160	.135	0.0	.160	.245	✓ .577
	3. Occasionally	-.138	-.112	-.295	-.169	.135	.135	-.192	.126	.070	-.354
	4. Rarely	.107		.338	.083	-.258	-.258	0.0	-.289	-.311	-.192
	5. Never	.102	.130		.276	.258		.302	.258	.236	.302
85.	I like to participate in a number of activities, whether or not I do particularly well.										
	1. Very often	.240	.193		.402	.378	-.258	.447	.160	.436	.302
	2. Often	-.138	-.112	.080	-.295	-.378	✓ .516	✓ -.667	-.126	-.169	-.169
	3. Once in a while	-.199	-.181	-.209	-.080	.135	0.0	.192	.135	-.044	0.0
	4. Rarely	.240	.257	.276	.276	0.0	-.480	.302	-.258	-.265	
	5. Never										

FIGURE 5.A-2 (Continued)

Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
86. If you are good enough you make your own odds.										
1. Strongly agree	.208	.231	.344	✓ .459	.126	.258	-.169	.135	.203	.333
2. Agree	-.107	-.130	-.217	-.338	-.126	-.258	.169	-.135	-.203	-.333
3. No opinion										
4. Disagree	-.259	-.256	-.201	-.201						
5. Strongly disagree										
87. Which type of commander would you most like to serve under?										
1. Tolerant on both the ground and in the air.	-.113	-.106	-.201	-.201						
2. Tolerant on the ground, demanding in the air.	-.246	-.233	-.268	-.121	.160	0.0	0.0	0.0	-.182	-.302
3. Tolerant in the air, demanding on the ground.										
4. Demanding on both the ground and in the air.	.284	.270	.350	.209	-.160	0.0	0.0	0.0	.182	.302
88. During the years you were growing up, how did the kind of work your father did change in importance, responsibility, and complexity?										
1. Increased a lot	-.106	-.112	-.295	.080	.378	.378	0.0	.250	.450	.507
2. Increased a little	.073	.093	.217	-.293	-.480	✓ -.577	✓ -.577	-.289	✓ -.685	✓ -.707
3. Remained about the same	.047	.035	.109	.109	0.0	.135	✓ .577	0.0	.203	.192
4. Decreased a little										
5. Decreased a lot										
6. I cannot say										
89. As an adolescent did you ever get in trouble for drinking?										
1. Very often										
2. Often										
3. Once in a while	.177	.163	.055	.344	.289	.405	0.0	.135	.245	.507
4. Rarely	.107	.092	.338	.083	-.258	.160	.192	-.258	.127	-.192
5. Never	-.237	-.210	-.352	-.352	0.0	✓ -.500	-.169	.135	-.310	-.354
90. There is a large difference between taking calculated risks and taking chances.										
1. Strongly agree	-.009	-.042	-.045	-.045	0.0	-.250	0.0	✓ .516	-.070	.169
2. Agree	-.024	.006	.045	-.080	-.126	.126	0.0	✓ -.516	-.044	-.354
3. No opinion										
4. Disagree										
5. Strongly disagree	.102	.108		.276	.258	.258			.236	.302

FIGURE 5.A-2 (Continued)

MCDONNELL DOUGLAS CORPORATION

Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
91. During your boyhood, did you live with your parents?										
1. I always lived with my father and mother except for trips, visits, etc.	-.024	.023	-.215	-.055	.160	-.258	-.192	0.0	.022	0.0
2. I lived with one of my parents; the other was frequently absent.	.146	.155	.402		-.378	.258	0.0	-.258	-.265	-.302
3. I lived with one of my parents; the other lived away from us, or was dead.	-.113	-.258	-.201	.055	.258		.302	.258	.236	.302
4. I visited, or was visited by, my parents but lived with relatives or elsewhere.										
5. I rarely or never saw my parents as they were dead or unknown; I lived with others.										
92. When you were in high school, how frequently did you have a feeling of wanting to leave home?										
1. Very often	.102	.108	.276		-.258	-.258	-.302	-.258	-.265	-.302
2. Fairly often	-.049	-.035	-.293	.083	.378	.160	0.0	0.0	.127	.447
3. Once in a while	.073	.042	-.080	.169	.250	-.126	.354	.258	.181	0.0
4. Never	-.076	-.055	.136	-.268	-.405	.135	-.169	-.160	-.167	-.169
93. As a boy, how were your finances taken care of?										
1. An allowance	-.113	-.106	-.201	-.201				-.258	.236	
2. My family giving me what I needed when I asked them for it.	-.033	-.023	.215	-.201	-.378	.258	-.447	0.0	-.022	0.0
3. Generally getting along without cash.	.146	.155				-.258	.302		-.265	
4. Earning my own money for some of the things I wanted.	-.187	-.195	✓ -.511	-.012	✓ .516	.126	.169	.289	-.044	.192
5. Earning my own money.	.177	.163	✓ .567	.055	✓ -.516	-.480	0.0	-.378	-.167	-.507
6. Getting allowance for doing specific family chores.	.070	.084	-.201	.215	.378	.378	0.0	.378	.344	.447
94. How old were you when you learned to drive a car?										
1. 12 years old or less	-.033	-.023	.215	-.201	-.378	-.378	-.302	-.378	-.265	-.302
2. 13 or 14	.081	.072	-.025	-.025	0.0	0.0	-.169	-.258	-.169	-.169
3. 15 or 16	-.123	-.125	-.258	-.012	.250	0.0	.169	✓ .500	.181	.333
4. 17 or 18	.146	.155	.276	.276	0.0	.378	.302		.236	
5. 19 or older										

FIGURE 5.A-2 (Continued)

Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
95. The population of the town I grew up in was:										
1. Under 1000	-.033	-.023	.055	-.201	-.258	-.378	-.302	-.258	-.265	-.302
2. 1000-5000	-.101	-.089	-.077	-.293	-.258			-.258		-.302
3. 5000-25,000	.208	.198	.215	✓ .459	.258	0.0	0.0	.405	.310	.507
4. 25,000-100,000	.140	.130	.083	.083	0.0	.135	0.0	-.258	.091	0.0
5. 100,000-500,000	✓ -.352	✓ -.345	-.369	-.179	.258		.302		.236	
6. Over 500,000	-.004	.012	.083	-.077	-.160	.160	0.0	.160	✓ -.491	-.302
96. When you were a boy, how much moving did your family do?										
1. Always lived in the same house except for trips, visits, etc.	.013	.035	-.179	-.025	.160	.289	-.302	-.160	-.033	.192
2. Lived in the same town and neighborhood but moved more than once.	-.247	-.240	-.077	-.293	-.258	-.258	-.302	-.258	-.265	-.302
3. Lived in the same town but changed neighborhoods at least once.	-.271	-.262	-.179	-.179	0.0		.302	-.258	-.022	-.302
4. Moved from one town to another at least once, but always in the same part of the country.	.107	.093	.083	-.077	-.160	-.258	-.354	.405	.091	.192
5. Moved from one town to another in various parts of the country.	.238	.231	.344	✓ .459	.126	.135	✓ .507	0.0	.091	0.0
6. Did not live together as I lived in an orphanage, or with foster parents, grandparents, other relatives, etc.										
97. What was the regular work of your father? (If the income of your family came chiefly from someone other than your father, show the regular kind of work of that person.)										
1. Professional	.059	.055	-.268	.382	✓ .630	.126	.333	.258	.310	.354
2. Proprietor, Manager, or Official	✓ -.333	-.320	-.350	✓ -.510	-.258	0.0	✓ -.577	.378	-.182	0.0
3. Clerical or Sales Worker	.024	.036	.055	.055	0.0	.480	.302	-.258	.236	.302
4. Skilled Worker or Foreman	.177	.163	✓ .459	.055	-.405	-.480	0.0	-.405	-.426	-.507
5. Semiskilled Worker										
6. Unskilled Worker	.146	.155	.276		-.258	-.258		0.0	.236	
98. During the years you were growing up, how did the standard of living of your family change?										
1. Increased a lot	.208	.198	.215	.055	-.160	-.135	0.0	-.258	-.311	-.192
2. Increased a little	-.237	-.210	-.352	.025	.378	-.126	-.169	0.0	.056	0.0
3. Remained about the same	.073	.054	.217	-.077	-.289	.378	.192	.289	.245	.192
4. Decreased a little										
5. Decreased a lot										
6. Fluctuated greatly, going up and down										

FIGURE 5.A-2 (Continued)

Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
99. How old were you when you first felt that you could come and go as you pleased without having to account too closely to your parents?										
1. 12 or younger	-.033	-.023	-.201	.215	.378	-.258	.447		.236	
2. 13 to 14	.208	.198	.344	.055	-.289	-.289	0.0	-.258	-.408	-.169
3. 15 to 16	-.220	-.231	-.258	-.382	-.135	-.126	-.354	0.0	-.044	0.0
4. 17 to 18	.036	.054	.083	.083	0.0	.480	0.0	.160	.436	.192
5. 19 to 20	.102	.108		.276	.258	.258		.258		
6. 21 or over										
100. In school, how frequently were you punished for bad conduct?										
1. Once or twice a week	-.164	-.240	-.293	-.077	.258		.302	.258	.236	.302
2. Almost every week	.107	.093	.083	-.077	-.160	0.0	-.192	-.135	-.311	-.169
3. Almost every month	.009	.042	.169	-.088	-.250	-.378	0.0	-.250	-.056	-.354
4. Once or twice a year	-.004	.012	-.077	.217	.289	.405	0.0	.378	.245	.447
5. Rarely										
6. Never										
101. How far did your father (or step-father or foster father) go in school?										
1. Grade school (8th grade or less)	.102	.108	.276		-.258	-.258		-.258		
2. Some high school	.102	.108						.258	.236	
3. Graduated from high school	.073	.054	.217	-.077	-.289	-.480	-.192	-.289	-.426	-.507
4. Some training after high school but not college	.102	.108					-.302	.253	-.265	
5. Some college	-.240	-.270	-.209	-.350	-.160	.135	.302	-.160	-.022	.192
6. Graduated from college	-.207	-.195	-.179	-.179	0.0	.378	0.0	.378	.344	.447
7. Advanced training after college graduation	.238	.263	.055	✓ .567	✓ .516	.135	.169	0.0	.203	0.0
102. While you were growing up, to what extent were the attitudes listed in Items A through G taught in your family?										
A. The father is the master of the house.										
1. Very great	-.049	-.035	-.077	-.077	0.0	-.258	0.0	-.258	-.182	-.447
2. Great	.047	-.004	-.025	-.025	0.0	0.0	0.0	.378	.203	.507
3. Not too great	-.090	-.065	-.209	.045	.258	.135	0.0	.135	-.167	-.192
4. Fairly small	.146	.155	.276	-.201	-.258	-.258	-.302	-.378	-.022	-.302
5. Not at all	-.033	-.023	.215		.378	0.0	.302	-.258		
6. I cannot say	.102	.108		.276	.258	.258			.236	.302
B. To strive hard to succeed										
1. Very great	.171	.130	.217	.217	0.0	-.126	-.169	0.0	-.056	.169
2. Great	-.138	-.112	-.169	-.045	.126	0.0	.169	-.126	-.169	-.354
3. Not too great	-.152	-.139	-.369	-.179	.258	.258	-.302	.258	.236	.302
4. Fairly small	.146	.155	.402		-.378	0.0	.302	-.258		
5. Not at all	.102	.108						.258	.236	
6. I cannot say										
C. To make present sacrifices for future gains.										
1. Very great	.267	.257	.276	✓ .508	.289	0.0	.192	-.160	.091	.354
2. Great	-.090	-.102	.169	-.350	✓ -.516	-.258	-.354	-.258	-.408	✓ -.667
3. Not too great	-.154	-.137	-.440	.012	.480	.160	.192	.480	-.022	.302
4. Fairly small	-.004	.012	.083	-.077	-.160	.160	0.0	-.160	.344	.302
5. Not at all	.102	.108						.258	.236	
6. I cannot say										

FIGURE 5.A-2 (Continued)

Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
While you were growing up, to what extent were the attitudes listed in Items A through G taught in your family? (Continued)										
D. To work hard at whatever I did.										
1. Very great	.009	-.029	.045	-.080	-.126	-.250	-.354	0.0	-.450	-.169
2. Great	-.024	.006	.045	.045	0.0	.126	✓ .577	-.258	.245	0.0
3. Not too great	.024	.036	-.201	.055	.258	.258	-.302	.378	.344	.302
4. Fairly small										
5. Not at all										
6. I cannot say										
E. To always take responsibility for my actions.										
1. Very great	✓ .378	✓ .355	✓ .459	.344	-.126	✓ -.500	-.192	0.0	✓ -.549	-.169
2. Great	✓ -.497	✓ -.481	✓ -.459	-.344	.126	✓ .500	.192	0.0	.350	.169
3. Not too great	.102	.108								
4. Fairly small	.181	.193						0.0	.344	
5. Not at all										
6. I cannot say										
F. To stand up for what you believe in.										
1. Very great	.291	.264	.083	✓ .454	.378	-.378	.169	0.0	-.310	0.0
2. Great	✓ -.362	✓ -.346	-.136	-.382	-.258	.289	.192	-.135	-.182	-.354
3. Not too great	.073	.093	.083	-.077	-.160	.160	-.447	.135	✓ .523	.447
4. Fairly small										
5. Not at all										
6. I cannot say										
G. To be somewhat on guard against people										
1. Very great	.146	.155		.402	.378	.258	.302		.344	.302
2. Great	-.062	-.045	-.025	-.025	0.0	0.0	-.192	-.289	-.182	0.0
3. Not too great	-.154	-.183	-.268	-.268	0.0	-.258	.192	.258	-.311	-.302
4. Fairly small	-.076	-.094	.136	-.268	-.405	-.160	-.192	.126	.091	0.0
5. Not at all	.267	.286	.267	.402	.160	.378	0.0	0.0	.127	0.0
6. I cannot say										
103. At what age did you first do the things listed in A through E?										
A. Go out on dates										
1. 12 or younger	.107	.130	.083	.083	0.0	-.126	0.0	-.480	-.167	0.0
2. 13 to 14	-.240	-.270	-.350	-.209	.160		.447	0.0	.127	0.0
3. 15 to 16	.231	.231	.217	.338	.126	.126	-.169	.378	-.056	-.169
4. 17 to 18	-.164	-.154	.083	-.293	-.378	0.0	-.302	0.0	.236	.302
5. 19 to 20										
6. 21 or over										
B. Neck										
1. 12 or younger	-.163	-.154	-.077	-.293	.258	-.378	-.302	-.258	-.387	-.302
2. 13 to 14	.047	.035	-.025	.109	.135	0.0	✓ .507	-.289	.091	0.0
3. 15 to 16	.081	.072	-.179	.109	.289	0.0	0.0	✓ .516	.070	.354
4. 17 to 18	-.062	-.045	.109	-.025	-.135	.289	-.302	0.0	.344	0.0
5. 19 to 20										
6. 21 or over										
7. Refused to answer	.102	.108	.276		-.258		-.302	-.258	-.265	-.302
C. Have sexual intercourse										
1. 12 or younger	.102	.108				-.258			-.265	
2. 13 to 14	-.033	-.023	.055	.055	0.0	0.0	.447			
3. 15 to 16	.145	.126	.215	.215	0.0	-.160	0.0	-.135	-.044	-.169
4. 17 to 18	.081	.072	-.025	-.179	-.160	-.135	-.192	.405	.245	.447
5. 19 to 20	-.114	-.094	-.121	.012	.135	.289	0.0	-.135	-.033	0.0
6. 21 or over	-.247	-.240	-.293	-.077	.258	.258			.236	
7. Refused to answer	.102	.108	.276		-.258		-.302	-.258	-.265	-.302

FIGURE 5.A-2 (Continued)

Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
D. Drink beer										
1. 12 or younger	-.247	-.240	-.293	-.293				-.258	.236	
2. 13 to 14	-.033	-.023	-.201	.055	.258	0.0	-.302	.258	-.022	.302
3. 15 to 16	.047	.035	.233	-.025	-.258	.160	0.0	0.0	-.290	-.169
4. 17 to 18	.059	.055	.012	.136	.126	-.126	0.0	-.258	-.033	-.169
5. 19 to 20	-.033	-.023	-.201	.055	.258	-.258	.447		-.022	
6. 21 or over	.146	.155	.276		-.258	.258	-.302	.378	.344	.302
E. Drink whiskey										
1. 12 or younger	-.259	-.256	-.201	-.201						
2. 13 to 14	.102	.108				-.258			-.265	
3. 15 to 16	.293	.314	✓ .508	.276	-.289	.160	0.0	-.289	-.033	-.192
4. 17 to 18	-.172	-.224	-.169	-.045	.126	.135	0.0	.126	.091	0.0
5. 19 to 20	.023	.036	-.201	.215	.378	-.160	.192	.258	-.022	.302
6. 21 or over	-.023	-.004	.025	-.179	-.160	0.0	-.192	0.0	.091	0.0
1J4. During the last five years you lived with your folks, how frequently did strong conflict take place between yourself and the people listed in Items A through H?										
*A Father (stepfather, etc.)										
1. A few times a week	-.033	-.023	-.201	.215	.378	.258	.302		.344	.302
2. At least once a week	.146	.108				-.258		.258		
3. At least once a month	.177	.198	.344	.344	0.0	.135	-.354	0.0	.091	0.0
4. A few times a year	.027	.055	-.268	-.268	0.0	-.258	0.0	0.0	-.292	0.0
5. Rarely	-.246	-.233	.012	-.268	-.289	.160	.302	-.160		-.302
6. Never	-.113	-.106	.055	-.201	-.258		-.302	-.258	-.265	-.302
7. Not applicable	.102			.276	.258		.302	.258	.236	.302
B. Mother (stepmother, etc.)										
1. A few times a week	-.033	-.023	-.201	.215	.378	.258	.302		.344	.302
2. At least once a week	.240	.257	.402	.402	0.0	0.0	-.447	0.0	-.182	-.192
3. At least once a month	.073	.054	.217	-.077	-.281	0.0	.192	-.289	-.387	-.192
4. A few times a year	-.062	-.089	-.025	-.025	0.0	0.0	.354	.135	.350	✓ .577
5. Rarely	-.154	-.137	-.440	-.268	.258	0.0	-.302	.378	-.033	
6. Never	-.033	-.023	.055	-.201	-.258	-.258	-.302	-.258	-.265	-.447
7. Not applicable										
C. Siblings										
1. A few times a week	.146	.155		.276	.258	.258			.236	.302
2. At least once a week	.240	.226	.276	.276	0.0	-.160	-.302	0.0	.127	0.0
3. At least once a month	.238	.231	.215	.344	.135	-.160	.169	.289	-.044	.192
4. A few times a year	-.449	-.441	✓ -.510	-.350	.258	0.0	.302		-.022	
5. Rarely	.107	.130	.338	-.077	-.405	-.135	-.354	-.378	-.167	-.333
6. Never	-.259	-.256	-.201	-.201						
7. Not applicable	-.164	-.154	-.077	-.077	0.0	.378	.302	.258		
D. Girl Friend										
1. A few times a week										
2. At least once a week	.102	.108		.276	.258	-.258	.302			
3. At least once a month	.107	.093	.083	.217	.135	0.0	.447	-.135	.070	.169
4. A few times a year	-.246	-.233	-.268	-.268	0.0	.258	-.192	.378	.127	.302
5. Rarely	.123	.125	.136	.012	-.126	-.126	✓ -.507	-.126	-.169	-.333
6. Never	.102	.108	.276		-.258	.258	.302			
7. Not applicable	-.259	-.256	-.201	-.201						
E. Teacher										
1. A few times a week										
2. At least once a week										
3. At least once a month	-.259	-.256	-.201	-.201						
4. A few times a year	✓ .343	✓ .342	✓ .508	.402	-.135	-.289	-.333	0.0	-.408	-.333
5. Rarely	-.091	-.090	-.136	-.012	.126	.258	.192	-.250	.203	.169
6. Never	-.207	-.195	-.179	-.369	-.258	0.0	0.0	.378	.127	.302
7. Not applicable	.102	.108		.276	.258		.302		.236	

FIGURE 5.A-2 (Continued)

Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
During the last five years you lived with your folks, how frequently did strong conflict take place between yourself and the people listed in Items A through H? (Continued)										
F. Friends										
1. A few times a week										
2. At least once a week	.102	.108		.276	.258	.258	.302			
3. At least once a month	-.164	-.154	-.077	-.293	-.258		-.302	0.0	-.387	-.302
4. A few times a year	.140	.093	-.293	.338	✓ .577	.135	.354	✓ .516	.350	✓ .577
5. Rarely	.009	.042	.295	-.209	✓ -.500	.126	-.354	✓ -.516	-.169	-.169
6. Never	-.164	-.154	-.077	-.293	-.258	-.258	-.302	0.0	-.022	-.302
7. Not applicable	.102	.108		.276	.258		.302		.236	
G. Coaches										
1. A few times a week										
2. At least once a week	.102	.108		.276	.258	.258			.236	.302
3. At least once a month										
4. A few times a year	.070	-.023	.055	.055	0.0	-.258	0.0	.160	-.022	0.0
5. Rarely	-.009	.029	.080	-.169	-.250	.126	-.169	-.378	.056	-.169
6. Never	-.154	-.137	-.121	-.121	0.0	-.135	.192	.160	-.182	0.0
7. Not applicable	.146	.155		.276	.258		0.0	.258	-.022	
H. Employer										
1. A few times a week										
2. At least once a week										
3. At least once a month										
4. A few times a year	.240	.226	.276	.276	0.0		0.0	.160	-.182	0.0
5. Rarely	.140	.130	.083	.217	.135	-.126	-.192	0.0	.091	0.0
6. Never	✓ -.352	✓ -.329	-.338	✓ -.454	-.126	.126	.169	0.0	.070	.169
7. Not applicable	.146	.155	.276	.276	0.0		0.0	-.258	-.022	-.302
105. If blocked from pilot training for minor physical reasons, such as 20/25 vision, color vision weakness, height or weight, I would:										
1. Accept the decision	-.259	-.256	-.201	-.201	0.0	0.0	0.0	0.0	0.0	0.0
2. Try to correct the defect in an acceptable fashion	-.140	-.130	-.083	-.217	-.135	-.289	-.169	-.135	0.350	-.333
3. Memorize the eye chart or otherwise fudge the results	-.076	-.055	-.121	.012	.135	.405	-.354	.258	.417	.333
4. Seek a waiver	-.013	-.035	-.233	.179	.405	-.135	✓ .507	-.135	.033	-.192
5. Use influence to get an exception made	-.198	-.183	-.268	-.440	-.258	0.0	0.0	-.289	-.033	0.0
106. How many brothers and sisters do you have? (Indicate both brothers and sisters.)										
1. No brothers	-.101	-.154	-.077	-.293	-.258	0.0	.302	.258	0.0	0.0
2. One brother	.201	.231	.217	.217	0.0	.258	✓ -.507	✓ .500	-.181	0.0
3. Two brothers	-.207	-.195	-.179	-.025	.160	-.160	0.0	-.258	-.022	0.0
4. More than two brothers	.212	.226	.402	.276	-.160	-.378	.302	-.378	-.022	-.302
5. No sisters	-.101	-.089	-.077	-.077	0.0	.378	.447	.258	.236	.302
6. One sister	-.125	-.102	-.080	-.209	-.135	.126	✓ -.577	-.135	-.169	.169
7. Two sisters	.013	-.004	.109	-.025	-.135	0.0	-.354	-.126	.070	-.333
8. More than two sisters	.212	.193	.276	.276	0.0	-.480	.302	0.0	0.0	0.0

FIGURE 5.A-2 (Continued)

MCDONNELL DOUGLAS CORPORATION

Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
107. Which of the following things have you had to plan for carefully and which you have succeeded in your goal?										
1. Being elected to office	-.076	-.055	-.268	.012	.289	0.0	-.192	0.0	-.311	0.0
2. Being invited to join a fraternity or club	✓ -.368	✓ -.350	✓ -.596	-.109	✓ .516	.258	0.0	.289	.203	.192
3. Obtaining an introduction to someone I wanted to meet	-.288	-.268	-.382	-.136	.258	0.0	-.192	.135	-.044	0.0
4. Succeeding in a school subject that was difficult for me	✓ -.418	✓ -.451	✓ -.508	✓ -.508	0.0	-.126	-.354	✓ .577	-.091	-.192
5. Getting ahead of someone with whom I was competing	.076	.094	-.012	.121	.135	.405	-.447	.405	.022	.192
6. Making a favorable impression upon someone	-.081	-.072	-.109	.025	.135	.405	-.354	✓ .516	.033	.192
7. Dating a particular girl	.114	.094	.268	.268	0.0	.378	-.192	.160	.033	.192
8. Getting into the fighter pilot program	.246	.233	.268	.268	0.0	-.160	-.447	.258	.033	-.302
108. Which of the following things have you trained and taught yourself to do well?										
1. Manual skills like woodworking, auto mechanics, etc.	.040	.055	-.136	-.012	.126	-.160	-.354	.289	-.245	0.0
2. Artistic skills like writing, sketching, painting, acting, etc.	-.062	-.045	-.179	.109	.289	.258	.192	0.0	.127	.447
3. To speak well in public	✓ -.551	✓ -.537	✓ -.797	✓ -.701	.135	.126	.169	.160	-.292	0.0
4. Typing, shorthand, etc.	-.105	-.087	-.369	-.179	.258	-.160	.302	-.258	-.265	.302
5. To overcome physical handicap	.181	.193	.402	.276	-.160	.258	.447	-.258	-.022	-.302
6. To acquire special ability to make a team	.144	.142	-.025	.233	.258	0.0	-.333	✓ .630	-.056	0.0
7. To become less shy in social relations	-.027	-.055	-.012	.121	.135	.135	0.0	.378	.167	0.0
8. To control my temper	-.187	-.195	-.258	.121	.378	.378	0.0	0.0	.056	.169
9. To adapt my personality to the requirements of the situation	-.231	-.231	-.083	-.338	-.258	-.126	.169	-.250	-.203	✓ -.707
109. In which of the following activities did you and your family, or members of the group with which you lived, engage fairly often? (Mark as many as apply.)										
1. Made such things as toys, play equipment, gifts, furniture together	✓ -.415	✓ -.458	-.430	✓ -.579	-.258	-.480	-.447	0.0	-.387	✓ -.447
2. Listened to music together	✓ -.403	✓ -.434	-.258	✓ -.651	-.480	-.405	-.192	0.0	-.311	✓ -.577
3. Entertained each other's friends	-.175	-.176	-.109	-.352	-.250	.126	-.333	-.126	-.056	-.192
4. Attended social gatherings	✓ -.469	✓ -.479	✓ -.701	✓ -.701	0.0	-.378	-.169	0.0	-.169	0.0
5. Talked about our day's activities together	-.144	-.176	.025	-.352	-.378	✓ -.516	-.169	-.135	-.181	-.192
6. Went on trips together	-.145	-.163	-.215	-.215	0.0	0.0	.447	.160	.033	0.0
7. Went on vacations together	.062	.045	.025	.369	.378	.160	-.302	0.0	.022	0.0
8. Engaged in sports together	-.123	-.125	-.136	-.258	-.126	✓ -.500	0.0	-.126	-.417	-.507
9. Included neighbors and friends in our good times, both mine and theirs	-.113	-.142	-.109	-.233	-.126	-.135	-.333	.135	.056	.192

FIGURE 5.A-2 (Continued)

MCDONNELL DOUGLAS CORPORATION

Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
110. When you lived with your folks, which of the following things did you do around the house? (Mark as many as apply.)										
1. Minor repairs such as wiring, carpentry	-.175	-.210	-.352	-.109	.250	-.126	-.169	.405	.044	0.0
2. Helping with cleaning	-.238	-.263	-.215	-.215	0.0	0.0	.447	.289	.169	.192
3. Scrubbing floors	✓ -.403	✓ -.434	-.258	✓ -.511	-.289	.135	0.0	-.135	-.387	-.192
4. Gardening and lawn mowing	-.181	-.193	-.276	✓ -.511	.258	0.0	-.302	-.135	.265	-.192
5. Putting on screens and storm windows	-.155	-.195	-.136	-.136	0.0	0.0	✓ -.667	.258	-.056	.169
6. Sweeping sidewalks and shoveling snow	-.107	-.130	-.217	-.083	.135	-.289	-.447	.480	.033	0.0
7. Chopping wood	-.040	-.017	.012	.012	0.0	.135	-.192	0.0	-.044	0.0
8. Taking out garbage	-.146	-.155	.012	.012	0.0	.258	-.192	0.0	.265	0.0
9. Doing general farm chores	✓ -.387	✓ -.377	-.350	✓ -.510	-.258	-.258	0.0	0.0	.236	0.0
10. None of the above	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
111. What is your attitude toward your health?										
1. I must watch my health	.036	.054	-.077	.083	.160	.480	-.302	0.0	.245	.192
2. I have frequent colds and ailments	-.259	-.256	-.201	-.201	0.0	0.0	0.0	0.0	0.0	0.0
3. I worry about my health	-.113	-.106	-.201	.055	.258	.258	-.302	.258	.236	.302
4. I hardly think of my health	.027	.020	.012	.136	.126	0.0	-.169	.126	.181	.333
5. I have several minor difficulties	-.033	-.023	-.201	.055	.258	.258	.302	.258	.236	.302
6. I am almost never sick	.006	-.020	.268	-.012	-.289	-.405	.192	.135	-.203	-.507
7. I try to take good care of my health	-.261	-.264	-.217	-.338	-.126	.126	-.169	0.0	-.310	.333
8. I am usually well and strong	-.109	-.126	-.055	.201	.258	0.0	-.169	.480	.022	0.0
9. I have fears about my future health	.024	.036	-.201	.215	.378	.480	-.302	0.0	.344	.447
10. I am a very healthy person	-.208	-.231	-.055	-.055	0.0	0.0	-.302	.480	-.127	0.0
112. When you were a boy, where did you spend your summer vacations?										
1. At home	-.081	-.072	-.109	-.109	0.0	0.0	0.0	.378	.169	.169
2. At camp	-.282	-.264	-.430	-.295	.160	0.0	✓ -.707	.289	-.311	-.192
3. At day camp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4. At my family's summer camp or home	-.164	-.154	-.293	-.077	.258	.258	-.302	.258	.236	.302
5. With other relatives in the country	-.105	-.089	-.179	-.025	.160	0.0	-.192	0.0	.033	0.0
6. With friends in the country	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7. At work	-.091	-.125	-.136	.121	.258	.258	-.169	.126	.292	.354
8. With relatives or friends in another town	-.246	-.233	-.268	-.121	.160	-.160	-.192	0.0	-.022	0.0
9. Taking occasional short trips	-.155	-.160	-.258	-.012	.250	.126	.333	.126	.181	.169
10. On a long trip	-.004	-.035	-.077	-.077	0.0	-.160	-.192	.289	-.182	0.0
11. On day trips with my family	-.301	✓ -.356	-.440	-.121	.378	-.258	.447	.258	.236	.302
12. On day trips for swimming, picnicking, etc., with my own crowd	-.244	-.264	✓ -.579	-.169	.480	-.160	.169	.289	.091	.447

FIGURE 5.A-2 (Continued)

Question	All Pilots	All Pilots Except 2 & 18	Worst Overall vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
113. When you were a boy, in which of the following activities did you engage?										
1. Checkers	-.036	-.054	.077	.077	0.0	0.0	0.0	0.0	.181	.302
2. Chess	.138	.112	.430	✓ .579	.258	.405	.192	.289	.426	0.0
3. Marbles	.090	.065	.209	.209	0.0	.135	.354	.135	.044	.192
4. Dominoes	.171	.164	.083	.338	.258	-.135	0.0	0.0	.181	.169
5. Bingo	-.076	-.094	.012	.012	0.0	-.258	-.192	-.135	-.169	0.0
6. Board games (Monopoly, etc.)	.004	-.012	.077	.293	.258	-.258	-.192	.389	-.169	0.0
7. Anagrams and puzzles	✓ -.362	✓ -.434	-.382	-.382	0.0	-.480	.447	-.135	-.033	-.192
8. Cards	-.013	-.035	.025	.025	0.0	0.0	-.302	.160	.182	.447
9. Dice	-.101	-.154	.083	-.293	-.378	-.378	-.302	-.160	-.387	-.447
10. Drama	-.247	-.240	-.293	-.077	.258	.258	-.302	.258	.236	.302
11. Band	.081	.072	-.025	.233	.258	.258	-.354	.258	.070	.333
12. School newspaper	.070	.084	.215	-.201	-.378	-.258	-.447	.160	-.182	✓ -.577
13. Schurch or social club	-.138	-.112	-.430	-.045	.405	.378	-.354	.258	.070	.169
14. Scouting	-.231	-.264	-.338	-.083	.258	.258	0.0	.405	.044	0.0
114. Which of the following things do you remember doing as a child?										
1. Having nightmares	✓ -.362	✓ -.388	-.136	✓ -.511	-.405	.135	-.354	0.0	.091	0.0
2. Eating only certain foods	-.062	-.089	.109	.025	-.135	.289	-.169	.135	.350	.354
3. Being timid away from home	.081	.107	.109	.109	0.0	.405	✓ -.507	.135	.181	.169
4. Fighting	-.056	-.102	-.080	-.080	0.0	.258	-.333	✓ .500	.070	.169
5. Crying	.036	.012	-.077	.083	.160	.289	0.0	.160	.436	.447
6. Doing cruel things	-.004	.012	-.077	.083	.160	✓ .577	0.0	-.160	.436	✓ .577
7. Snitching things	-.114	-.137	-.121	-.121	0.0	.289	-.169	.289	.350	.354
8. Playing hookey	.107	.093	.338	-.293	✓ -.577	-.289	✓ -.577	-.258	-.167	-.354
9. Biting fingernails	-.152	-.139	-.025	-.369	-.378	0.0	-.447	-.289	-.311	-.447
10. Having temper tantrums	-.004	.012	-.077	-.077	0.0	.289	0.0	-.160	-.022	0.0
11. Throwing up when angry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12. Hating your father or mother	-.101	-.089	-.293	-.293	0.0	.258	0.0	-.378	.236	.302
13. Telling lies to avoid punishment	-.023	-.004	-.025	-.179	-.160	0.0	-.192	0.0	.091	-.192
14. Running away from home	-.049	-.035	-.293	.083	.378	.160	-.302	.160	.127	.302
15. None of these	-.062	-.045	-.179	.109	.289	0.0	✓ .577	0.0	.127	0.0
115. In which of the following activities did you and family, or members of the group with which you lived, engage fairly often?										
1. Played games together	-.231	-.264	-.217	✓ -.454	-.250	-.126	-.354	.135	-.310	0.0
2. Read aloud	-.271	-.262	-.369	-.369	0.0	-.378	-.302	0.0	-.387	-.302
3. Went to movies together	✓ -.383	✓ -.396	-.217	✓ -.568	-.378	-.250	0.0	-.378	-.167	-.169
4. Went for walks together	-.198	-.233	-.121	-.440	-.378	-.480	-.302	0.0	-.311	-.447
5. Went on picnics and outings	-.201	-.231	-.338	-.217	.126	-.258	0.0	0.0	.044	.354
6. Went for rides together	-.123	-.160	-.136	-.136	0.0	-.250	-.169	.250	-.056	-.333
7. Went swimming, fishing, boating, skiing, skating, etc., together	-.140	-.164	-.217	.077	.289	.126	.192	.135	.167	-.169
8. Sang together	.070	.036	.055	.055	0.0	-.258	0.0	.160	.127	0.0
9. Went to ball games and other athletic events together	-.047	-.035	.369	-.109	-.480	.160	-.354	0.0	-.091	-.447
10. Shopped together	-.155	-.195	-.012	-.258	-.250	0.0	✓ .507	.378	-.056	-.169
11. Went to church together	-.059	-.055	-.136	-.136	0.0	.135	-.354	.378	-.070	.169
12. Went to museums, exhibits, concerts, plays, etc., together	-.199	-.224	-.080	-.209	-.135	0.0	0.0	.289	-.022	0.0
13. Did housework together	-.024	-.029	-.045	-.209	-.258	-.126	✓ -.845	.126	-.292	-.169
14. Worked on hobbies together	-.105	-.139	.109	-.369	-.480	0.0	-.354	.289	-.182	0.0
15. Worked in the garden or yard	-.047	-.035	.025	-.109	-.135	.160	✓ -.507	0.0	-.245	-.302
16. Watched television	-.073	-.093	.077	-.083	-.160	.258	-.192	0.0	.022	.302

FIGURE 5.A-2 (Continued)

Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
116. Which of the following activities have you engaged in fairly often?										
1. Football	-.036	-.054	.077	.077	0.0	.378	0.0	0.0	.265	0.0
2. Baseball	-.144	-.176	-.233	.179	.405	.258	.333	.258	.408	.192
3. Softball	-.081	-.107	.025	.179	.160	0.0	-.354	.135	.167	-.447
4. Swimming	.114	.094	-.012	.268	.289	.289	0.0	.289	.182	.192
5. Hockey	-.271	-.262	-.369	-.179	.258	.258	-.302	.378	-.265	0.0
6. Roller skating	.208	.198	.215	-.201	-.378	-.135	0.0	0.0	-.311	-.192
7. Ice skating	-.076	-.094	-.268	.258	✓ .516	.258	-.192	.405	.091	.192
8. Boxing	.240	.257	.402	.276	-.160	.289	0.0	-.160	-.182	.192
9. Wrestling	✓ .350	✓ .324	✓ .459	✓ .459	0.0	.126	.169	.250	.056	.507
10. Basketball	-.091	-.125	-.136	.121	.258	.378	-.169	.250	✓ .528	.333
11. Soccer	.109	.126	.055	.344	.289	.289	✓ -.577	.160	-.033	0.0
12. Track	-.024	-.029	.045	.045	0.0	.250	✓ -.507	-.126	-.070	.192
13. Skiing	.009	-.029	-.080	.295	.378	.378	0.0	.378	✓ .528	.507
14. Sailboating	.123	.125	.136	✓ .511	.405	✓ .516	-.169	0.0	.408	.354
15. Canoeing	.070	.084	.055	.215	.160	.378	-.447	.289	-.182	0.0
16. Skeet shooting	-.113	-.106	-.201	.055	.258	.258	0.0	0.0	.236	.302
17. Marksmanship	-.154	-.233	-.268	-.268	0.0	✓ -.674	0.0	.160	-.426	-.192
18. Tennis	-.261	-.296	-.338	-.217	.126	.250	✓ -.507	.135	-.070	0.0
19. Gymnastics	.024	.036	.055	.055	0.0	.258	-.447	.160	-.182	0.0
20. Spelunking	-.259	-.256	-.201	-.201	0.0	0.0	0.0	0.0	0.0	0.0
21. Sky diving	.212	.193	.276	0.0	-.258	-.160	-.302	.378	-.022	.302
22. Motocross	.070	.036	.215	.055	-.160	.160	-.302	.289	-.022	0.0
23. Dirt Biking	.266	.263	.215	.344	.135	.258	.192	0.0	.203	.354
24. Handball	✓ -.403	✓ -.483	-.382	-.382	0.0	-.289	-.192	.135	-.167	0.0
25. Racquetball	-.301	-.313	-.233	-.352	-.126	.126	-.302	✓ -.500	-.044	-.333
26. Scuba diving	-.207	-.195	-.025	-.369	-.378	.258	-.447	.160	-.182	0.0
27. Auto racing	.024	-.023	.055	-.201	-.258	-.160	-.447	.378	-.022	0.0
28. Weight lifting	-.045	-.065	.045	-.209	-.258	-.126	-.169	0.0	✓ -.648	-.169
29. Surfing	.293	.286	.402	.276	-.160	-.135	0.0	-.258	-.311	-.192
30. Calisthenics	✓ .321	✓ .329	✓ .568	.338	-.258	.135	-.169	-.126	-.310	0.0
31. Horseback riding	.070	.084	.215	.055	-.160	✓ .577	0.0	.160	.236	.447
32. Water skiing	.288	.268	.012	✓ .651	✓ .674	.289	.192	.258	.311	✓ .577
33. Hang gliding	.102	.108	0.0	0.0	0.0	-.258	.302	0.0	-.265	0.0
34. Soaring	.181	.155	.276	.402	.160	.378	0.0	.480	.344	.447
35. Diving	.177	.163	.055	.344	.289	.289	-.169	.405	.310	✓ .707
117. Regarding the status of my parents:										
1. My father is deceased	-.152	-.195	-.179	-.025	.160	.378	.447	.378	.436	.302
2. My father is living and I see him from time to time.	-.081	-.072	.025	.025	0.0	-.258	-.169	-.289	-.203	-.354
3. My father is living but we *have not kept in touch.*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4. My mother is deceased.	-.033	-.023	-.201	.055	.258	.258	0.0	0.0	.236	0.0
5. My mother is living and I see her from time to time.	-.238	-.263	-.215	-.055	.160	-.258	0.0	0.0	.033	-.192
6. My mother is living but we have not kept in touch.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7. My family now includes my father and stepmother or foster mother.	.102	.108	0.0	0.0	0.0	-.258	.302	0.0	-.265	0.0
8. My family now includes my mother and stepfather or foster father.	.146	.155	0.0	0.0	0.0	-.258	-.302	.258	-.022	-.302
9. None of the above is true of me.	.102	.108	.276	0.0	-.258	.258	-.302	.258	.236	.302

FIGURE 5.A-2 (Continued)

Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs Instructors	Best Overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
118. Why did you get interested in being a fighter pilot?										
1. My father was a fighter pilot.	-.247	-.240	-.293	-.293	0.0	0.0	0.0	-.258	.236	0.0
2. There were openings when I finished undergraduate pilot.	.146	.155	.402	0.0	-.378	.258	0.0	-.258	-.265	-.302
3. I first got interested in ROTC	.102	.108	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4. I got interested through movies and books.	✓ -.333	-.320	-.209	-.350	-.160	.160	0.0	.289	.245	.192
5. I had a long time interest in aviation and space flight.	.199	.181	.080	✓ .510	.480	-.160	0.0	.480	.265	0.0
6. Other	✓ -.333	✓ -.377	-.209	-.350	-.160	0.0	-.447	.289	.344	.447
119. When you unexpectedly have "time on your hands," what do you usually do?										
1. Sit down and relax.	-.138	-.148	-.295	-.295	0.0	0.0	0.0	.378	.070	.192
2. Find some absorbing task do do.	-.040	-.017	-.121	.012	.135	-.258	-.333	0.0	-.408	-.192
3. Find some work to do.	-.073	-.112	-.045	-.045	0.0	-.378	-.333	.250	-.181	0.0
4. Seek some kind of entertainment.	-.027	-.055	-.136	.268	.405	0.0	✓ .507	.126	.169	0.0
5. Find someboty do talk with.	.024	.036	-.201	.055	.258	0.0	-.302	.258	-.022	.302
6. Go drinking.	-.101	-.089	-.293	.083	.378	0.0	.447	.258	.236	.302
120. If I had been blocked from entry into undergraduate pilot training for administrative reasons, I would have:										
1. Accepted an alternative service school.	.146	.108	0.0	.276	.258	-.258	.302	.258	.236	0.0
2. Appealed the decision to appropriate authorities.	-.201	-.231	-.217	-.217	0.0	.378	0.0	.258	.167	.354
3. Tried to use influence of senior military officers or a congressman.	.107	.054	-.077	.338	.405	.258	-.192	✓ .516	.450	✓ .707
4. Accepted alternate duty and continued to reapply.	-.024	-.029	-.209	-.080	.135	✓ -.500	.447	-.135	.070	0.0
For the remaining items, subjects were to assign a name from the list below. Correct responses are as indicated.										
A. Bishop N. Gabreski B. Bong O. Mocharnuk C. Barkhorn P. Foss D. Krupinski Q. Galland E. Levine R. Sakai F. Bader S. Youngling G. Ota T. Pokryshkin H. Fitzgerald U. Milan I. Marseille V. Lacey J. Rickenbacker W. Hartmann K. Rudel X. Koshedub L. Nishizawa Y. Akamatsu M. McConnell										
121. America's leading WWI Ace. (J)	-.107	-.130	-.217	-.083	.135	0.0	0.0	.258	.033	.192
122. Highest scoring German Ace in WWII. (K)	✓ -.407	✓ -.417	✓ -.459	-.344	.126	.126	.169	.378	.292	.507
123. Second highest scoring German Ace in WWII. (C)	-.247	-.240	-.293	-.077	.258	.258	0.0	0.0	.236	0.0
124. Top American dual Ace for WWII and Korea. (N)	-.301	-.290	-.268	-.268	0.0	-.160	-.302	-.258	-.182	-.447
125. Highest scoring WWI Canadian Ace. (A)	-.244	-.307	-.430	.209	✓ .630	0.0	.354	.289	.450	.354

FIGURE 5.A-2 (Continued)

	Question	All Pilots[1]	All Pilots[1] Except 2 & 18	Worst Overall vs Instructors	Best overall vs Instructors	Overall Score	Aggressiveness	Headwork	Tactical Maneuvering	Airmanship	Tactics Syllabus Grades
126.	Highest scoring American Ace of all times. (B)	✓ -.367	✓ -.403	-.430	-.169	.289	0.0	.447	.160	.350	0.0
127.	Popular British Ace in WWII. (U)	.102	0.0	0.0	.276	.258	0.0	.302	.258	.236	.302
128.	Highest scoring American Ace in the Korean war. (M)	-.199	-.224	-.350	.045	.405	-.289	.354	.160	.203	-.192
129.	Most famous Stuka pilot. (K)	-.301	-.290	-.268	-.268	0.0	-.378	.302	0.0	-.022	-.302
130.	Mild mannered hero of the battle of Britain. (V)	-.259	-.256	-.201	-.201	0.0	0.0	0.0	0.0	0.0	0.0
131.	Fighter pilot who flew even after losing both legs. (F)	-.301	✓ -.350	-.352	-.352	0.0	-.126	-.169	✓ .500	.056	.169
132.	American WWII Pacific Ace who became a governor. (P)	-.155	-.195	-.258	-.012	.250	-.258	0.0	.378	.169	.169
133.	Japan's highest scoring Ace to survive the war. (R)	-.023	-.045	-.179	.233	.405	-.160	✓ .577	0.0	.285	0.0
134.	Ace of Lea Wing. (G)	.181	.193	.276	.276	0.0	-.258	.302	-.258	-.022	-.302
135.	Leading Japanese Ace in number of kills. (L)	-.023	-.045	-.025	-.025	0.0	-.289	.302	-.160	.127	-.302
136.	Swashbuckling Ace of JG-52. (D)	.102	.108	0.0	.276	.258	.258	0.0	0.0	.236	0.0
137.	Luftwaffe General of the Fighter Command. (Q)	-.269	-.278	-.352	.025	.378	-.126	.169	.258	.408	.333
138.	Top scoring Russian Ace. (X)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
139.	Most famous Soviet Ace. (T)	-.033	-.106	-.201	-.201	0.0	-.258	0.0	.258	0.0	0.0
140.	Legendary German Ace in North Africa. (I)	✓ -.528	✓ -.520	-.430	-.430	0.0	.378	-.302	.258	.344	.302
141.	Japanese Ace who defined discipline. He had his flight alarm set up in a nearby brothel.	-.152	-.139	-.025	-.179	-.160	-.160	-.302	-.160	-.022	0.0

FIGURE 5.A-2 (Continued)

MCDONNELL DOUGLAS CORPORATION

APPENDIX 5.B

PILOT LIFE INVENTORY QUESTIONNAIRE
(Short Form)

Section 1

1) Before you entered the Armed Forces, in what type of house did you and your wife (you and your parents, or you alone) live?

1. A private, one family house which we owned.
2. A private, one family house which we rented.
3. An apartment in a residential apartment house.
4. A condominium which we owned.

2) How often do you seek advice and aid from other people?

1. Very often
2. Often
3. Once in a while
4. Rarely
5. Never

3) How frequently has the thought entered your mind that other people dislike you or something about you?

1. Very often
2. Often
3. Once in a while
4. Never

4) In general, divorce settlements are too favorable to the woman.

1. Strongly agree
2. Agree
3. No opinion
4. Disagree
5. Strongly disagree

5) I like to tell other people what I think of them.

1. Very much
2. Somewhat
3. Very little
4. Not at all

6) Sometimes in combat your own command and control can be your worst enemy.

1. Strongly agree
2. Agree
3. No opinion
4. Disagree
5. Strongly disagree

7) I like to be asked to settle disputes between others.

1. Very much
2. Somewhat
3. Very little
4. Not at all

8) How often do you make use of credit or loans of over 30 days?

1. Never
2. Rarely
3. Once in a while
4. Fairly often
5. Often

9) I like to do things my own way, regardless of criticism or convention.

1. Very much
2. Somewhat
3. Very little
4. Not at all

10) How difficult for you were changes from one school or college to another?

1. Difficult and disagreeable
2. Somewhat difficult and disagreeable
3. Easily enough made
4. Fun
5. I did not make these kinds of changes

11) It is very important to be successful in things you try to do.

1. Strongly agree
2. Agree
3. No opinion
4. Disagree
5. Strongly disagree

12) As a boy, how frequently did you take a dare?

1. Almost always
2. Usually
3. Sometimes and sometimes not
4. Almost never
5. Never

13) The difference between the combat effective pilot with no kills and a few kills is often a matter of luck.

1. Strongly agree
2. Agree
3. No opinion
4. Disagree
5. Strongly disagree

14) Mastering the flying techniques was the easier part of the training program.

1. Strongly agree
2. Agree
3. No opinion
4. Disagree
5. Strongly disagree

15) How frequently do you borrow money from personal friends?

1. Very often
2. Fairly often
3. Once in a while
4. Rarely
5. Never

16) Before you were married when you dated one girl fairly regularly, did you date other girls at the same time?

1. Very often
2. Often
3. Once in a while
4. Rarely
5. Never

17) It bothers me to lose a game.

1. Very much
2. Somewhat
3. Very little
4. Not at all

18) Responsibility for birth control rests with the woman.

1. Strongly agree
2. Agree
3. No opinion
4. Disagree
5. Strongly disagree

19) Sports like auto racing are not too dangerous if you have the skill.

1. Strongly agree
2. Agree
3. No opinion
4. Disagree
5. Strongly disagree

20) Flying with your head is as important as flying with your hands, e.g., having the coordination skills needed to fly well.

1. Strongly agree
2. Agree
3. No opinion
4. Disagree
5. Strongly disagree

21) A fighter pilot will live or die on the basis of his own competence.

1. Strongly agree
2. Agree
3. No opinion
4. Disagree
5. Strongly disagree

22) During actual combat a good pilot is likely to be:

1. Calm throughout the combat
2. Somewhat nervous before and calm during combat
3. Tense and alert at all times
4. Apprehensive but doing his best despite it

23) A man's devotion to flying must be tempered by his devotion to his family.

1. Strongly agree
2. Agree
3. No opinion
4. Disagree
5. Strongly disagree

24) After a serious fight or argument I:

1. Calm down quickly
2. Feel weak and shaky
3. Do not think about the incident much
4. Have difficulty falling asleep
5. Keep going over in my mind what I should have done or said

25) When involved in making group decisions, the group will usually agree with my opinion.

1. Very often
2. Often
3. Once in a while
4. Rarely
5. Never

26) In sports or games, when you have a compelling lead over your opponent do you tend to ease up?

1. Very often
2. Fairly often
3. Once in a while
4. Rarely
5. Never

27) As a boy, how were your finances taken care of?

1. An allowance
2. My family giving me what I needed when I asked for it
3. Generally getting along without cash
4. Earning my own money for some of the things I wanted
5. Earning my own money
6. Getting allowance for doing specific family chores

28) What was the regular work of your father? (If the income of your family came chiefly from someone other than your father, show the regular kind of work of that person.)

1. Professional - such as architect, artist, musician, author, chemist, teacher, professor, doctor, dentist, lawyer, military officer, etc.
2. Proprietor, Manager, or Official - such as a store owner, wholesale dealer, manufacturer, farm owner, builder, company official, banker, government official or inspector, etc.

43) I like to participate in a number of activities, whether or not I do particularly well.

1. Very often
2. Often
3. Once in a while
4. Rarely
5. Never

44) There is a large difference between taking calculated risks and taking chances.

1. Strongly agree
2. Agree
3. No opinion
4. Disagree
5. Strongly disagree

45) It is often better to give in and avoid a fight than to try to have things your own way.

1. Strongly agree
2. Agree
3. No opinion
4. Disagree
5. Strongly disagree

46) I like to supervise or direct the actions of others.

1. Very much
2. Somewhat
3. Very little
4. Not at all

SECTION 2

For the following group of questions, mark as many responses as apply.

47) If blocked from pilot training for minor physical reasons, such as 20/25 vision, color vision weakness, height or weight, I would:

1. Accept the decision
2. Try to correct the defect in an acceptable fashion
3. Memorize the eye chart or otherwise fudge the results
4. Seek a waiver
5. Use influence to get an exception made

48) In which of the following activities have you an and your family, or members of the group with which you lived, engaged fairly often?

1. Made such things as toys, play equipment, gifts, furniture together
2. Listened to music together
3. Attended social gatherings
4. Talked about our day's activities together
5. Went on trips together
6. Engaged in sports together

49) Which of the following things do you remember doing as a child?

1. Having nightmares
2. Being timid away from home
3. Fighting
4. Crying
5. Doing cruel things
6. Snitching things
7. Playing hookey
8. Biting fingernails
9. Telling lies to avoid punishment
10. Running away from home
11. None of these

50) Which of the following activities have you engaged in fairly often?

1. Football
2. Baseball
3. Softball
4. Swimming
5. Hockey
6. Roller Skating
7. Ice skating
8. Boxing
9. Wrestling
10. Basketball
11. Soccer
12. Track
13. Skiing
14. Sailboating
15. Canoeing
16. Skeet shooting
17. Marksmanship
18. Tennis
19. Gymnastics
20. Spelunking
21. Sky diving
22. Motocross
23. Dirt biking
24. Handball
25. Racquet ball
26. Scuba diving
27. Auto racing
28. Weight lifting
29. Surfing
30. Calisthenics
31. Horseback riding
32. Water skiing
33. Hang gliding
34. Soaring
35. Diving

51) Why did you get interested in being a fighter pilot?

1. My father was a fighter pilot
2. There were openings when I finished undertraduate pilot training
3. I first got interested in ROTC
4. I got interested through movies and books
5. I had a long time interest in aviation and space flight
6. Other

52) If I had been blocked from entry into undergraduate pilot training for administrative reasons, I would have:

1. Accepted an alternative service school
2. Appealed the decision to appropriate authorities
3. Tried to use influence of senior military officers or a congressman
4. Accepted alternate duty and continued to reapply

28) (Continued)

3. Clerical or Sales Worker - such as work in a store or office, agent, salesman, bookkeeper, stenographer, technical assistant, etc.
4. Skilled Worker or Foreman - such as mason, carpenter, electrician, mechanic, tailor, conductor, baker, foreman in factory, farm or mine, military enlisted man, etc.
5. Semiskilled Worker - such as apprentice, factory operative, sailor, chauffeur, delivery man, attendant, etc.
6. Unskilled Worker - such as laborer in factory, farm, or construction, fisherman, longshoreman, elevator man, etc.

29) How far did your father (or stepfather or foster father) go in school?

1. Grade school (8th grade or less)
2. Some high school
3. Graduated from high school
4. Some training after high school but not college
5. Some college
6. Graduated from college
7. Advanced training after college graduation

30) Have you found yourself in a situation where you just didn't know what to do?

1. Very often
2. Often
3. Once in a while
4. Rarely
5. Never

31) While you were growing up, to what extent was the attitude that you should always take responsibility for your actions taught.

1. Very great
2. Great
3. Not too great
4. Fairly small
5. Not at all
6. I cannot say

32) At what age did you first drink whiskey.

1. 12 or younger
2. 13 to 14
3. 15 to 16
4. 17 to 18
5. 19 to 20
6. 21 or over

33) As a child (under 12) I:

1. Had few or no fights
2. Had several fights
3. Fought frequently

34) As a youth (12 to 17) I:

1. Had few or no fights
2. Had several fights
3. Fought frequently

35) How many fights did you have from age 18 or older?

1. 0
2. 1 or 2
3. 3 to 5
4. 5 to 10
5. More than 10

36) The population of the town I grew up in was:

1. Under 1000
2. 1000-5000
3. 5000-25,000
4. 25,000-100,000
5. 100,000-500,000
6. Over 500,000

37) How old were you when you had your first regular paid job, part-time or full time?

1. 12 years or less
2. 13 to 15
3. 16 to 18
4. 19 or older

38) When did you first get interested in being a fighter pilot?

1. In grade school
2. In high school
3. In college
4. In undergraduate pilot training

39) To get into the fighter pilot program it is excusable to conceal potential major physical disabilities such as diabetes or a heart murmur.

1. Strongly agree
2. Agree
3. No opinion
4. Disagree
5. Strongly disagree

40) In fights that you have been in, were your opponents:

1. From the same neighborhood
2. From across town
3. From another town
4. This does not apply since I never fought

41) Have you been ejected from the Officer's Club?

1. Several times
2. A few times
3. Once or twice
4. Never

42) As an adolescent did you ever get in trouble for drinking?

1. Very often
2. Often
3. Once in a while
4. Rarely
5. Never

53) Which of the following things have you had to plan for carefully and which you have succeeded in your goals?

1. Being elected to office
2. Being invited to join a fraternity or club
3. Obtaining an introduction to someone I wanted to meet
4. Succeeding in a school subject that was difficult for me
5. Getting ahead of someone with whom I was competing
6. Making a favorable impression upon someone
7. Dating a particular girl
8. Getting into the fighter pilot program

54) Which of the following things have you trained and taught yourself to do well?

1. Manual skills like woodworking, auto mechanics, etc.
2. Artistic skills like writing, sketching, painting, acting, etc.
3. To speak well in public
4. Typing, shorthand, etc.
5. To overcome physical handicap
6. To acquire special ability to make a team
7. To become less shy in social relations
8. To control my temper
9. To adapt my personality to the requirements of any situation

55) Which of the following describe you when you were in high school?

1. A varsity athlete
2. Class officer
3. In the top 1/3 of my class
4. A member of several clubs
5. A leader (officer) in some school club or organization
6. Active in student government

56) Which of the following describe you when you were in college?

1. A varsity athlete
2. Class officer
3. In the top 1/3 of my class
4. A member of several clubs
5. A leader (officer) in some school club or organization
6. Active in student government

57) Which of the following characterize your parents' supervision of you when you were growing up?

1. Strict
2. Fair
3. Lenient
4. Permissive
5. Harsh
6. Cruel

APPENDIX 6.A

DIFFERENTIAL MANEUVERING SIMULATOR (DMS)
DATA REDUCTION PROGRAMS

The data analysis package is based on 56 variables employed by the DMS at a preselected rate during the mission, usually every 0.5 second (see Figure 6.A-1). At the end of a series of runs, these data are transferred to a magnetic tape for further analysis. The programs used can be broken with three major categories: (1) Pretest programs

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VARIABLE	DESCRIPTION	UNIT
1	CODE NUMBER OF DATE, RUN, PILOT, AND AIRCRAFT	-
2	TIME FROM START OF RUN	SECONDS
3	RANGE	FEET
4	RANGE RATE	FEET/SECOND
5	INTEGER FLAG FOR GUN/MISSILE DATA FOR SPHERE A	-
6	INTEGER FLAG FOR GUN/MISSILE DATA FOR SPHERE B	-
7	X INERTIAL POSITION OF SPHERE A	FEET
8	Y INERTIAL POSITION OF SPHERE A	FEET
9	ALTITUDE OF SPHERE A	FEET
10	X INERTIAL VELOCITY OF SPHERE A	FEET/SECOND
11	Y INERTIAL VELOCITY OF SPHERE A	FEET/SECOND
12	TIME RATE OF CHANGE OF ALTITUDE OF SPHERE A	FEET/SECOND
13	EULER YAW ANGLE OF SPHERE A	DEGREES
14	EULER PITCH ANGLE OF SPHERE A	DEGREES
15	EULER ROLL ANGLE OF SPHERE A	DEGREES
16	NORMAL LOAD FACTOR OF SPHERE A	"G"s
17	LATERAL LOAD FACTOR OF SPHERE A	"G"s
18	ANGLE OF ATTACK OF SPHERE A	DEGREES
19	ANGLE OF SIDESLIP OF SPHERE A	DEGREES
20	BODY ROLL RATE OF SPHERE A	RADIANS/SECOND
21	BODY PITCH RATE OF SPHERE A	RADIANS/SECOND
22	BODY YAW RATE OF SPHERE A	RADIANS/SECOND
23	WEIGHT OF SPHERE A	POUNDS
24	THRUST OF SPHERE A	POUNDS
25	SPECIFIC EXCESS POWER OF SPHERE A	FEET/SECOND
26	FORE/AFT STICK POSITION OF SPHERE A	-
27	RIGHT/LEFT STICK POSITION OF SPHERE A	-
28	RUDDER PEDAL POSITION OF SPHERE A	-
29	THROTTLE POSITION OF SPHERE A	-
30	DUMMY WORD	-
31	DUMMY WORD	-
32 TO 56	REPEATS WORDS 7 TO 31 FOR SPHERE B	-

FIGURE 6.A-1 VARIABLES STORED ON DIFFERENTIAL MANEUVERING SIMULATOR DATA TAPE

which provide information for pilot briefings; (2) daily summary data of simulation runs; and (3) post-test programs which provide analysis of sets of runs for pilots, starting conditions, and other parameters. The pretest programs provide two digital models of Air Combat Maneuvering (ACM), the Adaptive Maneuvering Logic (AML) and the Analytical Simulation of Tactical Air Combat (ASTAC). The models provide a comparison of aircraft in ACM and indicate the outcome of the maneuvering given, the starting conditions and the aircraft capabilities. Other programs yield data on specific excess power during maneuvers, constant excess power between the two aircraft, and other energy management summaries as a function of Mach, and altitude. These programs are used to generate information for the pilots on the relative weaknesses and strengths of the aircraft being evaluated. The daily use programs analyze the single run data on a day-by-day basis. They provide a check on the operation of the simulator as well as a basis for the final evaluation of the tests. A list of these programs can be found in Figure 6.A-2. The major data reduction package in this series (HASTE) provides time history plots of all major variables and events, gun firing and missile hits, histogram plots, graphical displays of selected variables, and positional advantage summaries. A list of these subroutines is presented in Figure 6.A-3. The post-test programs are primarily concerned with measures of mission effectiveness such as aircraft weapons and offensive performance. (See dashed boxes in Figure 6.A-2.) They yield summaries of time kill zones and probability of kill data. They can provide single-run as well as multi-run data analysis.

Another test design innovation used by NASA is to run a series of engagements using the basic aircraft on an equal basis as part of the test design. Thus, during the F-4 aircraft studies, all pilots were run against each other using identical F-4 aircraft. This served as a baseline to evaluate the pilot effects across subject groups and studies.

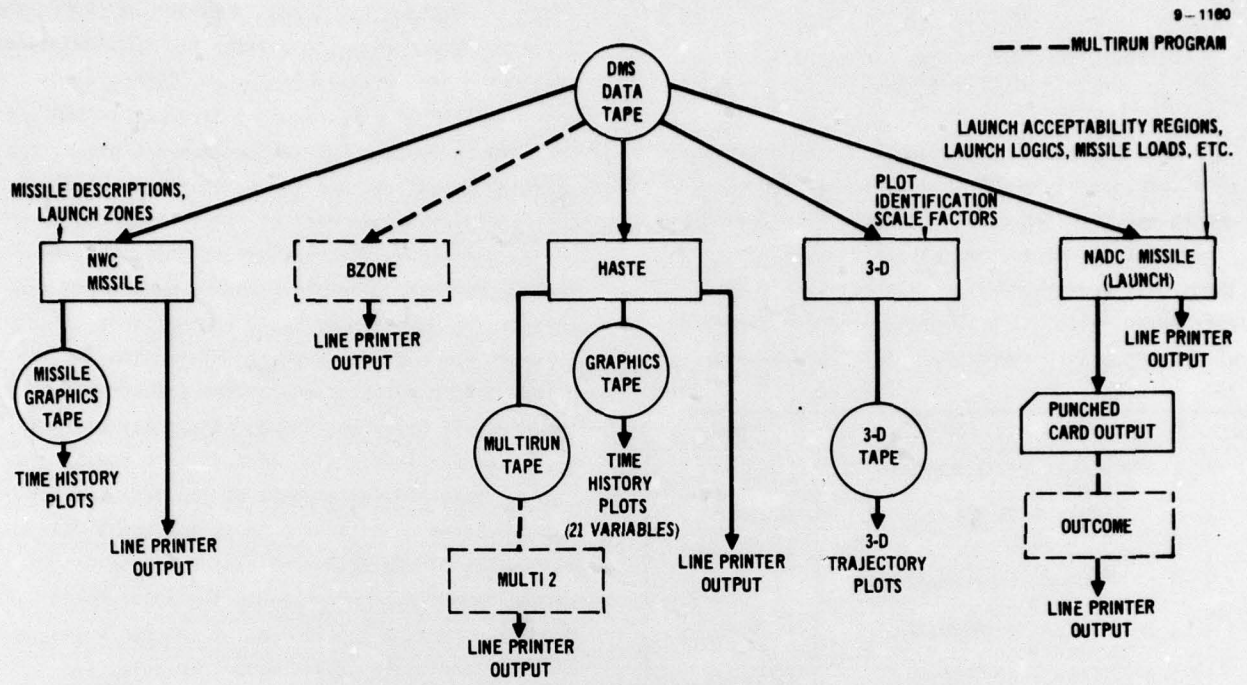


FIGURE 6.A-2 PROGRAMS USING DMS RESULTS

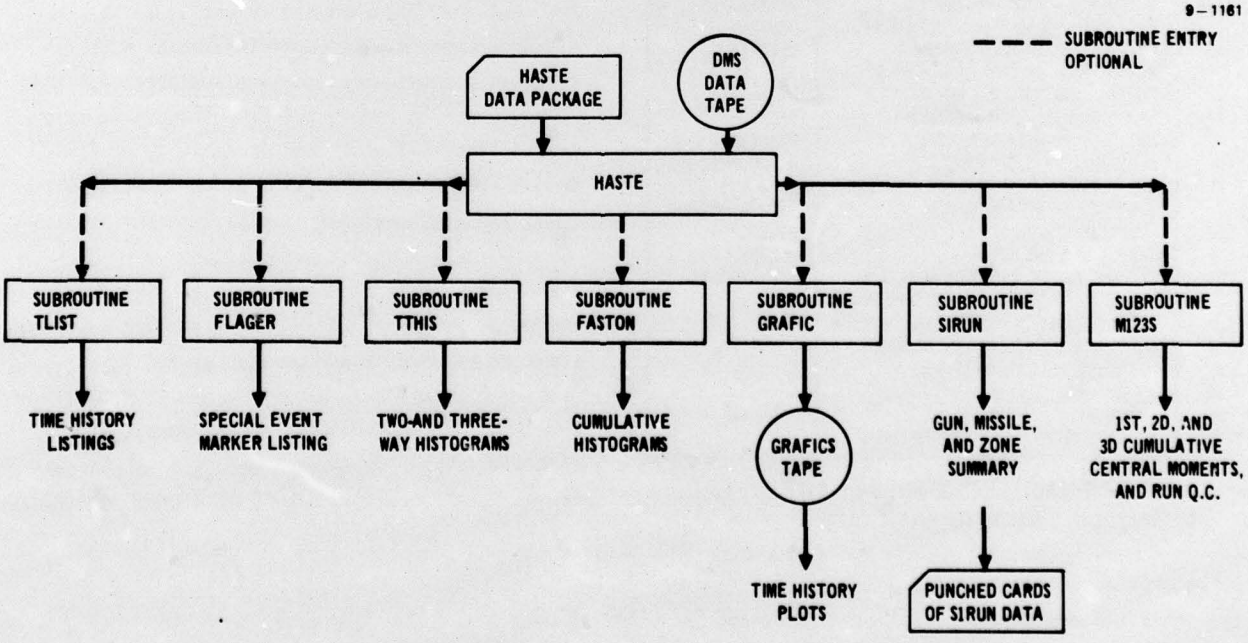


FIGURE 6.A-3 MAIN SUBROUTINES USED IN HASTE AND TYPES OF OUTPUT PROVIDED

APPENDIX 6.B

ADAPTIVE MANEUVERING LOGIC COMPUTER MODEL FOR AIR-TO-AIR COMBAT

Computer models for air combat generally fall into two types: the specific which generates optimum paths from specific initial conditions to specific end conditions; and the general which attempts to utilize the classic maneuver which most fighter pilots would use in a given situation. Both have significant drawbacks when applied to interactive combat situations. The specific models tend to be too specific, requiring complex iterative processes to generate a solution for only one of an infinite series of situations. The time and computer capacity required to solve such models make them impractical for real-time applications. The general model fails because many situations arise in air-to-air combat where no classical maneuver is the appropriate response. The program has no good response to these cases. At best, the classical maneuvers are general best solutions to specific problems in air combat maneuvering. In addition, these programs can require considerable modifications when aircraft characteristics are changed. The Langley Research Center chose to pursue an alternate approach called Adaptive Maneuvering Logic (AML) which would use some desirable characteristics of both the general and specific approaches but develop along lines essentially different from either.

6.B.1 AML MODEL DESCRIPTION

Rather than using classical maneuvers such as a high-speed yo-yo, scissors, etc., the program uses simpler, more elemental maneuvers. These elemental maneuvers consist of segments of circular flight paths lying in a plane. The flight path is specified by the throttle setting and the percentage of available load factor. The bank angle is chosen such that the flight path remains in the desired plane. The aircraft continues to fly in the specified plane until a new maneuver is chosen. When this occurs, the aircraft transitions to a new plane of flight by rolling until its wings are properly aligned to cause all net forces to lie in the new plane. The minimum time that an aircraft must fly in a maneuver plane is an input parameter to the program. It appears that one second intervals are sufficiently short to allow flexibility in reevaluating the tactical situation for possible maneuver changes.

This approach resembles the classic maneuver approach using smaller, more general maneuver segments. When these segments are put together, they often resemble the classic maneuvers; however, they are tailored as responses to the specific maneuvers of the piloted aircraft. A simplified flow of the AML is given in Figure 6.B-1. The program uses a

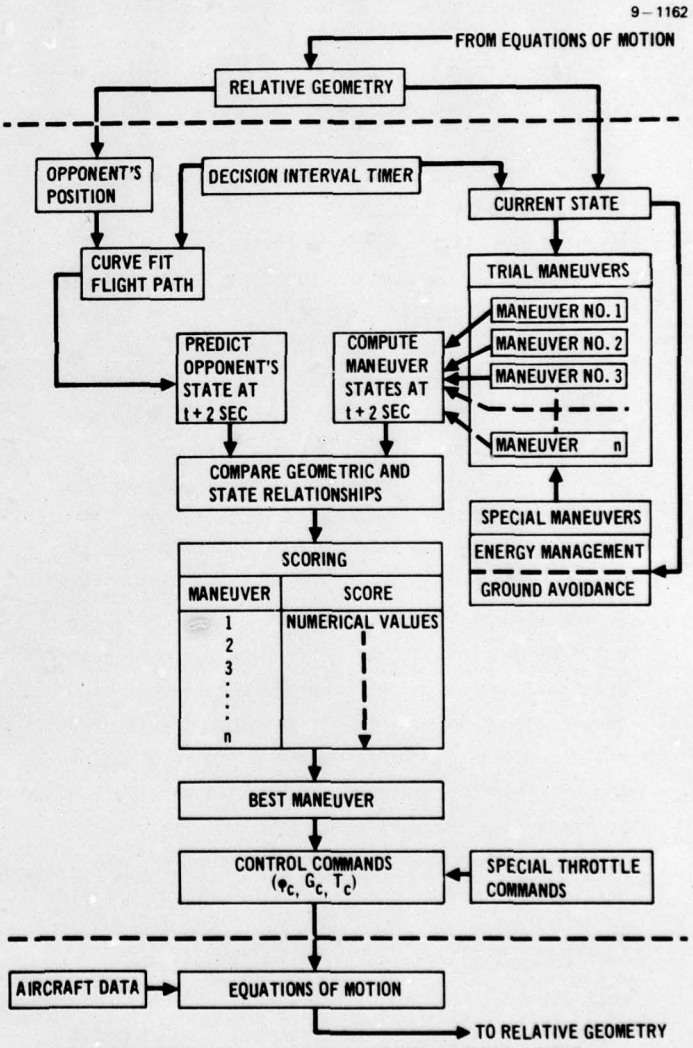


FIGURE 6.B-1 ADAPTIVE MANEUVERING LOGIC FLOW DIAGRAM

fixed logic to decide which maneuver to make next by predicting the future state of its opponent over a short time interval. It then computes what its state would be if it performed each of several optional maneuvers over the same time period. The computed state of each trial maneuver is compared with the predicted state of the opponent, and the most promising trial maneuver is chosen as the next to be performed.

When the program makes maneuvering decisions, it evaluates the standard elemental maneuver options available as a function of the current tactical situation. A separate priority logic is also included for ground avoidance.

Under normal circumstances, the program evaluates some or all of the following maneuvers: continuing the maneuver it is currently performing; maximum load factor turn in its current plane; maximum load factor turns in planes banked 10° to either side of the current plane of flight; flying straight; maximum load factor turns in the "intercept maneuver plane" (the "intercept maneuver plane" is defined as the plane which contains the computer-controlled aircraft's current velocity vector and the predicted position of the opposing aircraft); maximum load factor turns in planes banked 10° to either side of the "intercept maneuver plane"; maximum load factor turns in planes banked 90° to either side of the "intercept maneuver plane"; and a turn with a load factor computed to yield a circular flight path in the "intercept maneuver plane" which will exactly intercept the opponent at his predicted position. The AML extrapolates the opponent's position (and other state variables) at the end of a preselected time interval, nominally two seconds, from the current time using a second-order curve containing the opponent's present and two previous positions.

For each trial maneuver, the program computes what the state of the aircraft under its control would be at the end of two seconds. The computed state variables resulting from each trial maneuver are then compared with the predicted state variables of the opponent through a set of questions which results in a numerical score, the Adaptive Maneuvering Logic Score (AMLS), and the maneuver with the highest score is chosen as the next to be performed. The questions are listed in Figure 6.B-2. A yes answer is given a score of one and a no answer a score of zero. Currently, no weighting function is used beyond the one or zero scoring system.

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QUESTIONS	ANSWERS YES	ANSWERS NO
1. IS OPPONENT IN FRONT OF ATTACKER	1	0
2. IS ATTACKER BEHIND OPPONENT	1	0
3. CAN ATTACKER SEE OPPONENT	1	0
4. IS OPPONENT UNABLE TO SEE ATTACKER	1	0
5. IS ATTACKER IN CERTAIN CONE BEHIND OPPONENT	1	0
6. IS OPPONENT NOT WITHIN CERTAIN CONE BEHIND ATTACKER	1	0
7. CAN ATTACKER FIRE AT OPPONENT	1	0
8. CAN OPPONENT NOT FIRE AT ATTACKER	1	0
9. IS ATTACKER CLOSING ON OPPONENT	1	0
10. IS ATTACKER'S LINE OF SIGHT ANGLE LESS THAN 60°	1	0
11. IS ATTACKER'S LINE OF SIGHT ANGLE DECREASING	1	0
12. IS ATTACKER'S SPECIFIC ENERGY RATE GREATER THAN −30.48 M/SEC	1	0
MAXIMUM AND MINIMUM SCORES	+12	0

FIGURE 6.B-2 GEOMETRIC AND STATE COMPARISONS FOR THE AML MODEL

6.B.2 AML RELIABILITY

Split-half correlations were run on two sets of four subjects who flew both against each other and against the computerized pilot model (see Figure 6.B-3). Data were available for three sets of six engagements, two for man against man and one for man against model missions. Reliability coefficients were generated for all combinations to check for sampling error. Although a number of changes in the simulator were made during the interval between this data set and the previously reported data set (see Section 6.5.3), it was felt that useful indicators of measurement consistency could be obtained. Comparing the reliability measures with those from the previous set ($r_{A,B}$), it was found that time on offence (TO) and time on offence with advantage (TOA) were still unreliable performance measures The AMLS measure yielded an almost identical reliability coefficient (.81 versus .82) to the first group of subjects further substantiating

its value as a performance measure (see Figure 6.1-16). Kills data were not available for this group.

Comparisons were made of all measures and combinations of groups (A, B, A+B/2 versus model) with the scores generated in the pilot versus model encounters. These comparisons serve as an indicator of whether the measures are evaluating the same thing and how well they are measuring it. While the correlations obtained were low, the lack of relationship is mitigated by a numer of factors and does not, at this time, eliminate the pilot model as a tool for evaluating pilot performance. The data used to generate these coefficients were obtained on an ad hoc basis and represent the results of a preliminary model. Both the model and the simulator have gone through another generation of improvements, and it is quite possible that new data will show a significantly improved relationship. A proper evaluation would require a blind study where pilots were not told whether their opponent was the model or another "live" pilot and a minimum of 12 subjects run over at least six engagements for both model and live encounters.

MEASURE	TIME ON OFFENSE			TIME ON OFFENSE WITH ADVANTAGE			ADAPTIVE MANEUVERING LOGIC SCORE		
SIMULATION	A[1]	B[2]	MODEL[3]	A	B	MODEL	A	B	MODEL
SUBJECT 1	89.9	102.4	106.6	30.4	39.2	48.1	5.2	5.0	5.2
2	89.7	126.8	127.5	31.7	51.7	58.6	5.4	5.5	5.6
3	110.6	83.2	88.3	26.9	15.5	19.6	4.9	4.7	4.6
4	119.1	91.8	98.8	52.4	35.0	37.8	5.4	5.8	4.9
5	132.4	148.3	126.2	51.0	77.3	47.8	5.5	6.2	5.3
6	97.8	90.8	138.7	23.2	17.7	71.5	4.8	4.8	5.8
7	122.6	103.1	127.6	48.7	32.1	57.3	5.1	4.9	5.5
8	100.2	149.2	119.8	29.5	63.8	61.6	5.0	5.7	5.3
MEAN	107.79	112.57	116.69	36.73	41.54	50.28	5.16	5.33	5.27
STANDARD DEVIATION	15.88	25.93	17.10	11.89	21.58	16.11	0.256	0.550	0.385
$r_{A, B}$[4]	0.07			0.38			0.81		
$r_{A, MODEL}$[5]			–0.08			–0.18			–0.05
$r_{B, MODEL}$[6]			0.41			0.23			–0.01
$r_{A \& B, MODEL}$[7]			0.30			0.10			0.01

1. RESULTS OF PILOTS VERSUS PILOTS IN SPHERE A OF DMS
2. RESULTS OF PILOTS VERSUS PILOTS IN SPHERE B OF DMS
3. MODEL – RESULTS OF AML VERSUS PILOTS
4. THE CORRELATION BETWEEN RESULTS IN A AND B
5. THE CORRELATION BETWEEN RESULTS IN A AND THE MODEL
6. THE CORRELATION BETWEEN RESULTS IN B AND THE MODEL
7. THE CORRELATION BETWEEN THE AVERAGE RESULTS IN A AND B, AND THE MODEL

FIGURE 6.B-3 RELIABILITY OF THE AML MODEL COMPARED TO EQUIVALENT RUNS USING LIVE PILOTS

APPENDIX 7.A

CONTRACTED PARAMETRIC PRICE COMPARISONS
OF VARIOUS ACES IMPLEMENTATION DEVICES

	$ (Thousands)
7.A.1 PAPER-AND-PENCIL TESTING - See Reference (a)	
o Sample Program (six month duration)	
Device general description for selection	
- Paper-and-Pencil Test	
o Labor	120
- Test development, administration and validation - Application of Pilot Life Inventory Questionnaire	
o Data Processing	10
o Materials	5
o Facilities: government furnished	0
o Total	135
o Complete ACES Program (three year duration)	1,350
7.A.2 AIR-TO-AIR COMBAT SIMULATOR - See Reference (b)	
Device general description for selection	
o 40 feet diameter training station projection sphere	
o A two place cockpit	
o Instructor console	
o Multiprocessor digital computer	
o One-on-one simulation capability	
o Target generators	
o Hydraulic control loading system	
o Pneumatic system	
o Equipment monitor station	
As proposed for training use by U.S. Navy	29,521
As modified for selection purposes	10,333

	$ (Thousands)
7.A.3 JOB SAMPLE SELECTION TEST DEVICES	
o Aerial Gunnery Device - See Reference (c)	
Device general description for selection	
- Combined cockpit/instructors station	
- Ten feet dome display system	
- Digital computer	
As proposed for training use in Reference (c)	
o Single unit	1,775
o Each subsequent unit	860
As modified for selection purposes	
o Single unit	1,625
o Each subsequent unit	785
o General Aviation Trainer Device - See Reference (d)	
Device general description for selection	
- General Aviation Trainer	
- Microcomputer system	
- Voice synthesizer and audio/visual system	
As proposed to Canadian Air Force	
o Single unit	400
o Each subsequent unit	100
For United States Air Force	
o Single unit	350
o Each subsequent unit	85
7.A.4 COMPLETE ACES PROGRAM	
o One set of paper-and-pencil tests	1,350
o One air-to-air combat simulator	10,333
o Two aerial gunnery simulators	2,410
o Four General Aviation Trainers	605
TOTAL	14,698*

*This figure does not include the cost for the development of situational tests. This cost will depend upon a number of factors, including the nature of the variable(s) being assessed and the complexity of the tests.

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DISTRIBUTION LIST

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LtCol Jack Dick (3)
517 Bowling Green Drive
Montgomery, Alabama 36109

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Director, Advanced Systems Division
Air Force Human Resources Laboratories
AFHRL/AS
Wright-Patterson Air Force Base, Ohio 45433

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Phoenix, Arizona 85112

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ACS/Studies and Analysis
Headquarters USAF
Washington, D.C. 20330

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AFTFWC
Nellis Air Force Base
Las Vegas, Nevada 89191

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AFHRL Flying Training Division
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Tactical Air Warfare Center
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Air Command and Staff College
Maxwell Air Force Base
Montgomery, Alabama 36112

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U.S. Air Force
ATC/XPTD
Randolph Air Force Base, Texas 78148

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Air Force Directorate of Plans and Programs
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AF/DPPTF, The Pentagon
Washington, D.C. 20330

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Air Command and Staff College
Maxwell Air Force Base, Alabama 36112

Dr. Martin Rockway
Technical Training Division
Air Force Human Resources Laboratory (AFHRL/TT)
Lowry Air Force Base, Colorado 80230

CAPT M. Sromek
65th FWF/57th TTW
Nellis Air Force Base
Las Vegas, Nevada 89191

Col Joseph Salvucci
Chief, Range Group
AFTFWC
Nellis Air Force Base
Las Vegas, Nevada 89191

Dr. Robert N. Schwartz
Assistant for Special Studies
Analysis and Evaluation Group
ACS/Studies and Analysis
Headquarters, USAF
Washington, D.C. 20330

Maj Steve Sellman
Air Force Military Personnel Center (AFMPC/DPMYO)
Randolph Air Force Base, Texas 78148

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Air Force Human Resources Laboratory/PES
Brooks Air Force Base, Texas 78235

Maj Jere Wallace
65th Aggressor Squadron
Nellis Air Force Base
Las Vegas, Nevada 89191

ARMY

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U.S. Army Research Institute
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Alexandria, Virginia 22304

Dr. Abraham Birnbaum
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5001 Eisenhower Drive
Alexandria, Virginia 22304

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Alexandria, Virginia 22304

Mr. Charles Gainer
Army Research Institute Field Unit
Fort Rucker, Alabama 36362

Col Frank Hart
Assistant Deputy Chief of Staff for Training
Headquarters, TRADOC
Fort Monroe, Virginia 23651

Dr. Leon Nawrocki
U.S. Army Research Institute
5001 Eisenhower Drive
Alexandria, Virginia 22304

Dr. Brian Shipley, Jr.
Army Research Institute Field Unit
Fort Rucker, Alabama 36362

Dr. Joseph Zeidner
U.S. Army Research Institute
5001 Eisenhower Drive
Alexandria, Virginia 22304

MARINE CORPS

Dr. A. L. Slafkosky
Scientific Advisor (Code RD-1)
Headquarters, U.S. Marine Corps
Washington, D.C. 20380

NAVY

LCDR S. J. Berkley
VF-114
FPO San Francisco, California 96601

Dr. Glenn L. Bryan
Office of Naval Research
Psychological Science Division
800 North Quincy Street
Arlington, Virginia 22217

Chief of Naval Education and Training
Naval Air Station
Pensacola, Florida 32508
Attention: Dr. Worth Scanland

CAPT Russel Davis JTTC
ACEVAL-AIMVAL
Nellis Air Force Base
Las Vegas, Nevada, 89191

LCDR Rick Doll
Naval Aerospace Medical Research Laboratory
Pensacola, Florida 32505

Dr. Marshall J. Farr, Director
Personnel and Training Programs
Office of Naval Research (Code 458)
Arlington, Virginia 22217

Dr. J. D. Fletcher
Navy Personnel Research and Development Center
(Code 9041)
San Diego, California 92152

LCDR Thomas Jones
Naval Aerospace Medical Research Laboratory
Pensacola, Florida 32505

Mr. Stephen C. Merriman
Engineering Psychology
Crew Systems Division
Naval Air Systems Command
Washington, D.C. 20361

CDR Dan MacIntyre
18 East Old Willow Road
Apartment 513 North
Wheeling, Illinois 60090

LCDR Norm McCoy (3)
15064 Oak Canyon Road
Poway, California 92064

Dr. Heber G. Moore
Program Admin. Aircraft Tech./HF
HQ Naval Material Command 0331
Navy Department
Washington, D.C. 20360

DISTRIBUTION LIST

NAVY (Continued)

Dr. Richard Oberlie
Navy Fighter Weapons School
Miramar, California 92145

Dr. James Regan
Technical Director
Navy Personnel Research and Development Center
San Diego, California 92152

Dr. Alfred F. Smode
Training Analysis and Evaluation Group
Code N-007
Orlando, Florida 32813

CAPT Clyde H. Tuomela
Director, Aviation Safety Programs
Naval Postgraduate School
Monterey, California 93940

OTHER DoD

Dr. Harold F. O'Neil, Jr. (2)
Program Manager
Cybernetics Technology Office
Defense Advanced Research Projects Agency
1400 Wilson Boulevard
Arlington, Virginia 22209

Dr. Jesse Orlanski
Institute for Defense Analysis
400 Army Navy Drive
Arlington, Virginia 22202

OTHER GOVERNMENT

Mr. Albert Meintel
Flight Dynamics Control Division
Human Factors Branch, Mail Stop 152D
NASA Langley Research Center
Hampton, Virginia 23665

OTHER INDIVIDUALS INCLUDING RETIRED MILITARY

MajGen John Alison, USAF (Ret.)
2438 Belmont Road, N.W.
Washington, D.C. 20008

Professor Earl A. Alluisi
Department of Psychology
Code 287
Old Dominion University
Norfolk, Virginia 23508

Col John R. Boyd, USAF (Ret.)
OSD/P&E
USAF, The Pentagon, Room 2C281
Washington, D.C. 20301

Dr. John Brackett
SofTech
460 Totten Pond Road
Waltham, Massachusetts 02154

Mr. James L. Brooks
2257 Mandeville Canyon Road
Los Angeles, California 90049

Dr. John Seeley Brown
Bolt, Beranek and Newman, Inc.
50 Moulton Street
Cambridge, Massachusetts 02138

Mr. Robert N. DeHaven
3718 Terrace View Drive
Encino, California 91436

Mr. Peter deLeon
The RAND Corporation
1700 Main Street
Santa Monica, California 90406

Dr. Donald Dodd
History Department
Auburn University
Montgomery Campus
Montgomery, Alabama 36109

Mr. Ralph E. Flexman
Director, Institute of Aviation
University of Illinois, Willard Airport
Sayoy, Illinois 61874

Mr. F. S. Gabreski
Plant 05, Dept. 930
Grumman Aerospace Corporation
Bethpage, New York 11714

BrigGen Frank L. Gailer, USAF (Ret.)
6011 Woodwick Drive
San Antonio, Texas 78217

Col William J. Hovde, USAF (Ret.)
13803 Briar Meadow Road
San Antonio, Texas 78217

Col James K. Johnson, USAF (Ret.) (12)
c/o Walter Nielson
4630 Corral Place
Las Vegas, Nevada 89109

Col William R. Jones, USAF (Ret.)
107 Broken Bough Lane
Shavano Park
San Antonio, Texas 78231

Dr. James M. Ketchel
Systems Development Department
Stanford Research Institute
Menlo Park, California 94025

Brig Gen Robin Olds, USAF (Ret.)
Box 1478
Steamboat Springs, Colorado 80477

Dr. Richard Pew
Bolt, Beranek and Newman, Inc.
50 Moulton Street
Cambridge, Massachusetts 02173

OTHER INDIVIDUALS INCLUDING RETIRED MILITARY
(Continued)

Dr. Wallace W. Prophet
President
Seville Research Corporation
400 Plaza Building
Pace at Fairfield
Pensacola, Florida 32505

Dr. Joseph W. Rigney, Director
Behavioral Technology Laboratories
University of Southern California
376 South Hope Street
University Park,
Los Angeles, California 90007

Col Raymond Toliver, USAF (Ret.)
5286 Lindley Avenue
Encino, California 91316

Mr. Norman Walker
336 Hungarford Dr.
Rockville, Maryland 20850

BrigGen David O. Williams, Jr., USAF (Ret.)
9207 Clearock Drive
Austin, Texas 78750

GENERAL OFFICERS

Gen Robert J. Dixon
Commanding General, Tactical Air Command
Langley Air Force Base, Virginia 23665

Gen Daniel James, Jr.
Commanding General
Aerospace Defense Command
Ent Air Force Base, Colorado 80912

Gen William W. Momyer, USAF (Ret.)
AF/CV, The Pentagon, Room 4C 1071
Washington, D.C. 20301

Gen John W. Roberts
Commanding General, Air Training Command
Randolph Air Force Base, Texas 78148

Gen F. Michael Rogers
Commanding General, USAF Logistics Command
Wright-Patterson Air Force Base, Ohio 45433